



JCAA/JG-PP Lead-Free Solder Project: Vibration Test

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1.0 Abstract

Vibration testing was conducted by Boeing Phantom Works (Seattle) for the Joint Council on Aging Aircraft/Joint Group on Pollution Prevention (JCAA/JG-PP) Lead-Free Solder Project under contract BM3419-01. The JCAA/JG-PP Consortium is the first group to test the reliability of lead-free solder joints against the requirements of the aerospace/military community.

A complete modal analysis was conducted on one test vehicle (the “Pathfinder” PWA) using a laser vibrometer system. This system measured velocities, accelerations and displacements of the PWA during the vibration test. The laser vibrometer data was used to determine the resonant frequencies of the “Pathfinder” PWA and the actual deflection shapes of the PWA during test. In addition, the strains generated during a 1 G sine dwell were calculated for 1053 points on the “Pathfinder” PWA.

After completion of the modal analysis, thirty test vehicles (in two batches of 15 test vehicles each) were subjected to the vibration test conditions. The input power spectral density was increased during the test at 60 minute intervals in an effort to fail as many components as possible within the time allotted for the test.

The solder joints on the components were electrically monitored using event detectors and any solder joint failures were recorded on a Labview-based data collection system. The time to failure of a given component attached with SnPb solder was then compared to the time to failure of the same component attached with lead-free solders.

After completion of the testing, all of the test vehicles were visually inspected. Broken component leads and other unwanted failure modes were documented.

2.0 Background

Recently, legislation has been passed in Europe to ban the use of lead (and other materials) in new electronics starting 1 July 2006. The legislation actually banning lead is called the RoHS (Restriction of Hazardous Substances). The legislation that governs the re-use and recycling of electronics waste is called the Waste from Electrical and Electronic Equipment (WEEE) Directive.

Japan also has become focused on lead-free electronics. Many of the major electronics companies (e.g., Hitachi, NEC, NTT, Panasonic) have announced lead reduction targets and the move to lead-free electronics is supported by JEITA (the Japan Electronics and Information Technology Industries Association). These companies view lead-free as a marketing tool that will allow them to gain market share from their foreign competitors.

Aerospace and military electronics are currently exempt from the European legislation. However, as the international commercial electronics industry changes over to lead-free technology in order to satisfy the European legislation, it will become increasingly difficult for aerospace and military programs to procure electronics made with SnPb solder. For this reason, a DoD sponsored consortium was founded in May of 2001 to

evaluate lead-free solders and finishes and to determine whether they are suitable for use in high reliability electronics. This consortium is jointly managed by the Joint Council on Aging Aircraft (JCAA) and the Joint Group on Pollution Prevention (JG-PP). The consortium's project is called the JCAA/JG-PP Lead-Free Solder Project and it boasts members from all branches of the Armed Services, NASA, Boeing, Rockwell-Collins, Raytheon, BAE Systems, ACI, Lockheed Martin, Texas Instruments, NCMS, Sandia National Labs, and Marshall Space Flight Center among others.

The consortium wrote a test plan called the Joint Test Protocol (JTP, Reference 1) which describes the testing to be done. The testing includes thermal cycling, thermal shock, vibration, mechanical shock, combined vibration/thermal cycling, electromigration, SIR, salt fog and humidity.

A test vehicle was designed and the lead-free solders to be tested were chosen. The solder selection process was documented in the Potential Alternatives Report (PAR, Reference 2).

The test vehicle was a six-layer circuit board 14.5 inches wide by 9 inches high by 0.090 inches thick (Figure 1). A break-off coupon populated with chip resistors and chip capacitors was attached to one side of the main test vehicle. With the break-off coupon removed, the main test vehicle was 12.75 in. by 9 inches in size and was populated with 55 components consisting of ceramic leadless chip carriers (CLCC's), plastic leaded chip carriers (PLCC's), TSOP's, TQFP's, BGA's, and PDIP's (Figure 2). The pads for the CSP's and the hybrids were not populated. The components contained internal wire bonds so that once mounted on the test vehicle, each component would complete an electrical circuit that could be monitored during testing. Failure of a solder joint would cause a break in the electrical circuit that could be detected by an event detector. Each test vehicle also had a daisy-chain of twelve 0.016 inch diameter plated thorough holes so that the reliability of the holes could be determined. The plated through holes were filled with solder during the wave solder operation. Each component location on the test vehicles was given a unique reference designator number.

The solder alloys selected for test were:

Sn3.9Ag0.6Cu for reflow and wave soldering (abbreviated as SAC)
Sn3.4Ag1.0Cu3.3Bi for reflow soldering (abbreviated as SACB)
Sn0.7Cu0.05Ni for wave soldering (abbreviated as SnCu)
Sn37Pb for reflow and wave soldering (abbreviated as SnPb)

The SAC alloy was chosen because extensive testing by NEMI suggests it is a viable candidate for use in lead-free commercial electronics. The SACB alloy was chosen because it was the best performer in the large 2001 NCMS study (Reference 3). The SnCu alloy was chosen because it has been widely used in Asia with good results. Finally, SnPb was included to act as the control alloy.

The test vehicles were divided into two types. The first type (named “Manufactured” test vehicles) were made using a laminate with a high glass transition temperature (Tg of 170 degrees C) and an immersion silver board finish. The “Manufactured” test vehicles were meant to be representative of a printed wiring assembly (PWA) designed for manufacture using lead-free solders and lead-free reflow and wave soldering profiles. Tables 1 and 2 list the components used on the “Manufactured” test vehicles and “Manufactured” control test vehicles; the finish on each component; and the solders used. The CLCC’s with a lead-free pad finish were produced by robotic dipping of gold-plated CLCC’s into the respective molten solders (Sn3.9Ag0.6Cu or Sn3.4Ag1.0Cu3.3Bi). The robotic dipping was done at Corfin Industries in Salem, NH.

The second type (named “Rework” test vehicles) were made using a laminate with a low glass transition temperature (Tg of 140 degrees C) and a tin/lead HASL board finish. The “Rework” test vehicles were meant to be representative of a typical tin/lead PWA that will have to be reworked using lead-free solders in the future. The “Rework” test vehicles were initially built using tin/lead solder and a tin/lead board finish and using typical tin/lead reflow and wave soldering profiles. Selected components on the “Rework” test vehicles were then removed; residual tin/lead solder was cleaned from the pads using solder wick; and new components were attached using a lead-free solder. Components on the “Rework” control test vehicles were reworked with tin/lead solder rather than a lead-free solder. In general, solder wire was used for reworking the components. The BGA’s, however, were replaced using flux only and the balls were reflowed using a hot air rework station to form the solder joints. Tables 3 and 4 list the components used on the “Rework” test vehicles and “Rework” control test vehicles; the finish on each component; the solders used; and which components were actually reworked.

It is very important to understand that during vibration testing, the vibration environment at a given location on a test vehicle can be very different from the vibration environment at a different location on the same vehicle during the same test. This means that only identical components in identical locations on identical test vehicles can be directly compared. It also implies that the test solder must be used on one set of test vehicles and the control solder on a second set of test vehicles.

Two hundred and five test vehicles were assembled at Boeing’s plant in Irving, Tx (now BAE Systems). One hundred and nineteen of these test vehicles were “Manufactured” PWA’s and eighty six were “Rework” PWA’s. Eight components were reworked on each of the “Rework” test vehicles (two BGA’s; two TSOP’s; two PDIP’s; and two TQFP-208’s). Thirty one of the assembled test vehicles were sent to Boeing in Seattle for vibration testing. These PWA’s consisted of 16 “Manufactured” test vehicles and 15 “Rework” test vehicles.

The reflow profiles used for the SnPb and the lead-free solder pastes are shown in Figures 3 and 4. A 6-mil laser cut stencil was used during paste application. The wave soldering profiles used for tin/lead and lead-free wave soldering are shown in Figures 5 and 6. Wave soldering with SnPb was done at Boeing-Irving and the lead-free wave

soldering was done at Vitronics-Soltec in New Hampshire. The rework profiles for removing and replacing the BGA's using a hot air rework station are shown in Figures 7 and 8. All rework was done at Boeing-Irving.

On the "Manufactured" test vehicles, some CLCC's were finished with SnPb (on the pads and in the castellations) which resulted in lead-free solder joints contaminated with Pb after assembly (i.e., components U9, U13, U22, U46 and U53). In addition, some of the TSOP's had a SnPb finish which also resulted in lead-free solder joints contaminated with Pb (i.e., components U16, U24, U26, U40 and U62). This mixing was done intentionally in order to determine the effects of lead-contamination upon lead-free solder reliability. Inductively coupled plasma (ICP) spectroscopy was used by Boeing to quantify the amount of Pb in the solder joints on two of the "Manufactured" test vehicles (see Table 5; Test Vehicle ID #'s 80 and 119). The solder joints were removed with a scalpel, dissolved in acid, and the solution was analyzed by ICP spectroscopy.

Similarly, on the "Rework" test vehicles, all of the solder joints contained Pb. The components that were reworked using lead-free solders picked up residual Pb from the pads on the test vehicles (i.e., TSOP's U12 and U25; BGA's U4 and U18; PDIP's U23 and U59; and TQFP-208's U3 and U57). Other components had lead-free finishes but since they were attached to the "Rework" test vehicles using SnPb solder, the final solder joints contained large amounts of Pb (CLCC's U9, U10, U13, U14, U17, U22, U45, U46, U52, U53; and BGA's U2, U5, U6, U21, U43, U44, U55, U56). Again, inductively coupled plasma (ICP) spectroscopy was used to quantify the amount of Pb in the solder joints on two of the "Rework" test vehicles (see Table 5; Test Vehicle ID #'s 158 and 186).

All of the ICP analyses appeared reasonable with the possible exception of the QFP-208 analysis. The copper content in the QFP-208 solder joints was 6.63% which is higher than expected. It is possible that the excess copper was removed from the test vehicle pads when the solder joints were cut from the test vehicle using a scalpel.

3.0 Objective and Approach

The objective of this study was to determine the effects of high vibration environments on the relative reliability of lead-free and tin/lead solder joints (i.e., which solder survived the longest). Modal data and strain data were also collected during this study in an effort to provide data that would be useful to those that may want to try to model the behavior of the JCAA/JG-PP test vehicle.

Thirty one test vehicles were delivered to Boeing for vibration testing. These consisted of 15 "Manufactured" test vehicles; 15 "Rework" test vehicles; and one "Pathfinder" test vehicle.

The "Pathfinder" test vehicle was tested first in order to:

- (1) Verify that the test setup was not susceptible to electronic noise

- (2) Verify that the test fixture would firmly hold the test vehicles even at the highest vibration levels
- (3) Verify that no signal wires would be broken during testing
- (4) Conduct a complete modal analysis of a “Manufactured” test vehicle (i.e., identify resonance frequencies and map the deflections of the test vehicle during test)
- (5) Map the strain field across a “Manufactured” test vehicle

The “Pathfinder” test vehicle (ID# 149) is shown in Figure 9. It was a “Manufactured” test vehicle made from a high Tg laminate and assembled with SnPb solder paste using components per Table 1. An accelerometer was attached to the vehicle as shown in Figure 9 in order to measure the response of the vehicle to the vibration inputs. The three test axes (x, y, and z) are indicated on the photograph.

Before any testing was conducted, the approximate first resonance frequency of the “Pathfinder” test vehicle was calculated as 82 Hz using the following equation (Reference 4, pg. 128). This equation is for a board that is firmly fixed on two opposite edges.

$$\text{Natural frequency} = 82 \text{ Hz} = \frac{3.55(D/\rho)^{0.5}}{a^2}$$

$$D = \frac{Eh^3}{12(1-\mu)}$$

$$\rho = \text{mass/area} = W/gab$$

$$a = \text{board width} = 12.75 \text{ in.}$$

$$b = \text{board height} = 9.0 \text{ in.}$$

$$h = \text{board thickness} = 0.093 \text{ in.}$$

$$E = \text{modulus of elasticity} = 4500000 \text{ lb/in}^2$$

$$W = \text{board weight} = 0.95 \text{ lbs}$$

$$\mu = \text{Poisson's ratio for epoxy/fiberglass} = 0.12$$

$$g = \text{gravity} = 386 \text{ in/sec}^2$$

An aluminum fixture was built that could hold up to fifteen test vehicles at one time although the “Pathfinder” vehicle was tested by itself (see Figure 10). Slots were cut into the fixture to accept wedgelocks (Calmark A260-8.80T2L) that were mounted on both ends of the test vehicles with screws. The wedgelocks were designed with a special locking feature to prevent loosening from vibration.

The electrodynamic shaker used for the test was an Unholtz-Dickie T1000W with a 360 KW amplifier controlled by a Spectral Dynamics 2550B Vibration Controller. The shaker input was controlled by three accelerometers (one on the top of the fixture; one near the bottom of the fixture; and one on the shaker).

Figure 11 shows the “Pathfinder” test vehicle mounted in the test fixture. A three-element stacked rosette strain gage (WK-03-060WR-350, Micro-Measurements) was mounted as shown to collect strain data in the x, y, and x-y directions. The end of the fixture was removed so that the “Pathfinder” test vehicle could be imaged using a laser vibrometer system (Polytec Scanning Vibrometer, Waldbronn, Germany). The laser vibrometer was used to measure velocities, accelerations, and displacements at 117 points on the bottom surface of the “Pathfinder” test vehicle during low level (6dB below the 9.9 Grms spectrum) random vibration in the z-axis (the axis perpendicular to the plane of the test vehicle). Figures 12 and 13 show the laser vibrometer as it scanned the surface of the “Pathfinder” vehicle.

The laser vibrometer measurements identified 18 resonance frequencies for the “Pathfinder” test vehicle. The laser vibrometer data was also used to calculate a mode shape for each of the resonances (see Appendix F). The most important resonances (i.e., most damaging) were at 72 Hz and at 411 Hz. The laser vibrometer data was used to map the actual movement (operating deflection shapes) of the test vehicle at 72 Hz and at 411 Hz (see Figures 14 and 15). The operating deflection shape at a given frequency differs from the pure mode shape at that frequency because the operating deflection shape contains contributions from other modes. Note that the measured natural frequency of 72 Hz compares well with the calculated natural frequency of 82 Hz.

The laser vibrometer was also used to take data at 1053 points on the surface of the “Pathfinder” vehicle during a 1 G sine dwell at each resonance frequency (in the z-axis). This data was used to calculate full field peak strains in the vehicle x-direction at 72Hz and 411 Hz (see Figures 16 and 17). At 72 Hz, the regions of maximum strain were down the centerline of the vehicle and along the edges of the vehicle (near the wedgelocks). The complete full field peak strain data is contained in Appendix G.

After collection of the modal and strain data, the “Pathfinder” test vehicle was subjected to random vibration in the z-axis only. The “Pathfinder” vehicle was exposed to one hour of a 9.9 Grms spectrum (see Figure 18 and Table 6). No testing was done in the x and y axes because the deflections in those axes were not expected to be large enough to result in component failures. The spectrum was then increased in 2.0 Grms increments, shaking for one hour at each level (in the z axis). The original plan was to stop at 20.0 Grms, but an additional level of one hour at 28.0 Grms was added to obtain more component failures.

No problems were noted with electronic noise, wire breakage, or loosening of the wedgelocks.

Each of the 55 components on the “Pathfinder” vehicle were individually monitored using an Analysis Tech 256STD Event Detector (set to a 300 ohm threshold) combined with Labview-based data collection software. The wires connecting the test vehicle to the event detector had to be glued to the surface of the test vehicle (Figure 9) to prevent them from flexing and breaking during the vibration test. In addition, the wire bundles from the test vehicle were firmly clamped to the fixture in order to prevent flexing and

breaking of the wires. All wire bundles were covered with a metallic shield to prevent electrical noise from the shaker from interfering with the event detectors.

Figure 19 shows x-direction strain vs. frequency (from a Fourier transform of the strain gage data collected during random vibration in the z-axis) for the “Pathfinder” vehicle. The strain at 72 Hz was much larger than that at 411 Hz which demonstrates that the 72 Hz resonance caused the most damage to the test vehicle.

The time to failure (in minutes) for each component on the “Pathfinder” board is shown in Figure 20. The random vibration spectrum was increased in amplitude every 60 minutes and the total length of the test was 420 minutes. Any component that did not fail during the test is shown as having survived 420+ minutes. Note that the components that failed first were those on the centerline of the vehicle and those down the sides of the vehicle (near the wedgelocks). Therefore, the first component failures coincide with the regions of highest strain as shown in Figure 16.

After the “Pathfinder” board was tested, the remaining thirty test vehicles were tested in two groups of fifteen vehicles each. The first group of fifteen vehicles were “Manufactured” vehicles and the second group of fifteen were “Rework” vehicles.

Figure 21 shows the fifteen “Manufactured” test vehicles mounted in the test fixture. Again, wedgelocks (torqued to 6 in-lbs) were used to clamp the edges of the test vehicles. Figure 22 shows the fixture mounted on the shaker table for testing in the y-axis. Figure 23 shows the fixture mounted for testing in the x-axis. Figure 24 shows the fixture mounted for testing in the z-axis. Figure 25 shows the four Analysis Tech Event Detectors used for detecting solder joint failures during the test. Each event detector had 256 channels and each component in test had its own channel. Each test vehicle had 55 components and one set of plated thorough holes that were monitored. A calibrated accelerometer was mounted on each test vehicle to record the resonance frequencies and the response of each test vehicle.

Each group of test vehicles was subjected to the vibration levels shown in Figure 18 and Table 6. The test consisted of one hour of vibration at 9.9 Grms in the y-axis, followed by one hour of vibration at 9.9 Grms in the x-axis, followed by one hour of vibration at 9.9 Grms in the z-axis. Then the test vehicles were subjected to additional vibration in the z-axis only, starting with one hour of vibration at 12.0 Grms. The vibration levels were then increased in 2.0 Grms increments, shaking at each level in the z-axis for one hour until completion of the 28.0 Grms run.

Figure 26 shows the shaker input into the “Manufactured” test vehicles and Figure 27 shows the typical response of a test vehicle (both during a 14.0 Grms run). Note that the response of the test vehicle differs greatly from the input PSD spectrum with the major test vehicle resonances occurring at 72 Hz and 411 Hz.

Figure 28 shows the displacement of a test vehicle vs. frequency (from accelerometer data during a 1 G sine sweep of a “Manufactured” test vehicle in the z-axis). This

illustrates that the most displacement (and therefore the most solder joint damage) occurs at 72 Hz which corroborates the strain gage data. The 411 Hz resonance results in approximately 40 times less displacement than occurs at 72 Hz.

The “Rework” test vehicles were made from a different laminate than that used for the “Manufactured” test vehicles. The difference in laminate stiffness shifted the major resonance for the “Rework” test vehicles from 72 Hz down to 65 Hz. Similarly, the 411 Hz resonance observed on the “Manufactured” vehicles was shifted down to 370 Hz on the “Rework” vehicles.

Each of the 55 components on each test vehicle were individually monitored using Analysis Tech 256STD Event Detectors (set to a 300 ohm threshold) combined with Labview-based data collection software. As with the “Pathfinder” vehicle, the wires connecting the test vehicles to the event detectors were glued to the surface of the test vehicles to prevent them from flexing and breaking during the vibration test. In addition, the wire bundles from the test vehicles were firmly clamped to the fixture in order to prevent flexing and breaking of the wires.

4.0 Results and Discussion

Table 7 shows the total percentage of component failures on the “Manufactured” vehicles after completion of each vibration level. Similarly, Table 8 shows the total percentage of component failures on the “Rework” vehicles after completion of each vibration level.

After completion of all vibration testing, the “Manufactured” and “Rework” test vehicles were visually inspected using a HYROX Hi-Scope Compact Micro Vision System (Model KH-2200 MD2). The main goal of the inspection was to document any broken or missing leads on leaded components. This was necessary so that failures due to solder joint cracking could be distinguished from failures due to lead breakage. The secondary goal of the inspection was to document any unusual solder joint failure modes.

Photographs of representative lead and solder joint failures are shown in Figures 29 through 35. The complete visual inspection results for each test vehicle can be found in Appendices A and B. Some components (TSOP’s and TQFP’s) tended to fall off of the test vehicles during testing (see Table 9). In addition, all wiring was visually inspected to verify that no signal wires had broken during the vibration test (a broken signal wire would look like a solder joint failure to the event detectors). No broken signal wires were found.

The time to failure for each component tested is given in the tables in Appendices C and D. Since only identical components in identical locations on identical test vehicles can be directly compared, each table shows only the test data for components with the same reference designation (i.e., components occupying the same location on each of the test vehicles). Since some of the “Manufactured” test vehicles were assembled with lead-free solders and some with tin/lead solder, we can do a direct comparison to determine which solder type performed better under vibration. The tables in Appendices C and D show the solder/component finish combinations that were tested and the number of test levels that

each survived. A “60” means that that particular component survived the entire 60 minute duration of the test at a given test level.

The results of the vibration testing are summarized in Tables 10 – 12. The solders were ranked according to which solder survived the longest for each component tested. The solder that survived the longest was assigned the number “1” and the color “green”. The next best solder was assigned a “2” and the color “yellow”. The solder that failed first was assigned the number “3” and the color “red”. In case of a tie, the two solders were assigned the same number and color. For those cases where it was not readily apparent which solder performed the best, Weibull plots of the data were used to help determine the ranking (see Appendix I).

Since the test conditions were changed during the test (i.e., the PSD was increased every 60 minutes), it was believed that the test data would not be suitable for Weibull analysis which requires that the test conditions remain constant. However, Weibull plots of the vibration data gave excellent line fits (see Figure 36 and the plots in Appendix H; only the z-axis data was plotted since the testing in the x and y axes probably did very little damage). This suggests that the actual strains experienced by the test vehicles did not track the input PSD levels. When Fourier analysis was performed on the strain gage data to yield the strains at each frequency, it became apparent that the x-direction strain at 72 Hz remained relatively constant above the 9.9 Grms test level during testing (see Figure 37). In addition, the Grms under the first resonance (72 Hz) peak (measured using accelerometer data) was very non-linear with respect to the input PSD level. This means that as the PSD levels were increased, the energy going into the test vehicles remained relatively constant rather than increasing. The cause for this non-linearity is not known but may have been due to frictional losses at the PWA/wedgelock/fixture interfaces. One possible culprit is the band of copper around the outermost edge of both sides of the test vehicles (see Figure 1). This band was coated with solder during the wave solder operation. The wedgelocks were mounted on the solder coated band and the solder may have acted as a lubricant which allowed the test vehicles to slide back and forth during vibration. This unexpected non-linearity does not have any real impact upon the results of the test, since the relative performance of the solders should not be affected.

The ideal case would have been for all lead-free solders to have survived longer than the SnPb control solder. This would have implied that the lead-free solders could be used for any design where SnPb solder was also acceptable. Unfortunately, the lead-free solders failed before the SnPb control in some cases. Although this does not mean that lead-free solders can not be used in high reliability electronics, it does imply that models for calculating the actual field lifetime of lead-free solder joints will need to be developed in order to verify that lead-free solders will survive for the required lifetime of a given circuit assembly design.

4.1 Observations (“Manufactured” Test Vehicles)

4.1.1 BGA-225’s

SnPb balls assembled with SnPb paste always outperformed SnAgCu (SAC) balls assembled with either SAC paste or SnAgCuBi (SACB) paste. SAC balls assembled with SACB paste performed better than SAC paste/SAC balls which is surprising since the composition of the final solder joints should be very similar in composition.

Similar results were observed when SnPb balls were assembled with SnPb, SAC or SACB paste. SnPb balls assembled with SnPb paste outperformed SnPb balls assembled with either lead-free paste (with the SAC paste showing the worst performance).

4.1.2 CLCC-20’s

A large percentage of the CLCC’s did not fail during the test. In those cases where there were enough failures to rank the solders, the combination of SACB paste/SACB part finish outperformed SnPb paste/SnPb part finish which in turn outperformed SAC paste/SAC part finish.

In those cases where the CLCC finish was SnPb combined with either SnPb paste, SAC paste or SACB paste, the combination of SACB paste/SnPb finish performed the best. Bismuth alloys combined with trace amounts of lead have been shown to fail prematurely in thermal cycling due to the formation of a low melting ternary 16Sn32Pb52Bi alloy (m.p. 96°C, Reference 5). Either the ternary alloy is not vibration sensitive or the formation of the ternary alloy was suppressed somehow by the large amount of lead in the final joints (approx. 17% by ICP analysis). The large amount of lead in the solder joints is due to the large amount of SnPb solder held by the castellations on each CLCC.

4.1.3 PDIP-20’s

When combined with a NiPdAu part finish, the Sn0.7Cu0.05Ni wave solder alloy (SnCu) was by far the best performer, followed by the SAC alloy and then SnPb.

When combined with a Sn part finish, the Sn0.7Cu0.05Ni wave solder alloy was still the best performer. Eutectic SnPb was the next best followed by SAC. SbPb appeared to perform much better (relative to the SnCu alloy) when combined with a Sn part finish rather than a NiPdAu part finish.

The PDIP solder joints tended to form circumferential cracks around the corner leads closest to the edge of the test vehicle. These leads are in a region of high stress as shown in Figure 16. Figure 29 shows a photograph of a cracked PDIP corner solder joint (SnPb solder/NiPdAu part finish). Figure 30 shows another cracked PDIP corner solder joint (SnPb solder/Sn part finish). Microsections revealed that the leads within the corner solder joints were also broken.

4.1.4 TSOP-50's

The TSOP's oriented parallel to the shorter side of the test vehicle (U12, U16, U26, and U29) tended to fall off during the testing (see Table 9). The TSOP's oriented perpendicular to the shorter side of the test vehicle (U24, U25, U39, and U40) did not fall off during the testing. The general failure mechanism for U12 and U26 was for all of the leads on the side nearest the board edge to come loose from the solder (see Figure 31). The TSOP was now free to rotate which caused the leads on the opposite side of the TSOP to break off. The general failure mechanism for U16 and U29 was for all of the leads on the side furthest away from the board edge to come loose from the solder (see Figure 32). The TSOP was now free to rotate which caused the leads on the side adjacent to the edge of the test vehicle to break off (see Figure 33). The effect of orientation upon TSOP failures may have been due to the greater radius of curvature change experienced by the foot of a TSOP lead when oriented perpendicular to the shorter edge of the vehicle versus the smaller radius of curvature change experienced when oriented parallel to the vehicle edge. The greater radius of curvature change would result in an earlier solder joint failure.

The orientation of the TSOP's may also have played a role in how well the solders performed and in their relative ranking. For example, with U12 (oriented parallel to the short vehicle edge) the relative solder ranking was SnPb > SAC > SACB. However, for U25 (oriented perpendicular to the short vehicle edge) the relative solder ranking was SAC > SACB > SnPb. These patterns were repeated for the same components on the "Rework" test vehicles which supports the hypothesis that there could be an orientation effect. For U29, both SAC and SACB were superior to SnPb but there were not enough failures to rank the two lead-free solders.

Contamination of the TSOP solder joints with lead gave mixed results. TSOP U26 (next to and oriented the same as U12), exhibited the same solder ranking as the uncontaminated U12, i.e., SnPb > SAC > SACB. TSOP U16 (next to and oriented the same as U29) exhibited a different solder ranking than its uncontaminated neighbor U29, i.e., SAC > SnPb > SACB. With U24, both lead-free solders outperformed the SnPb control, the same as with its uncontaminated neighbor U25.

4.1.5 PLCC-20's

Most of the PLCC's did not fail during the vibration testing. Only U15 had enough failures to allow ranking of the solders which suggests that PLCC's are relatively resistant to solder joint damage in high vibration environments. On U15, SnPb outperformed SACB which in turn outperformed SAC. No cracked or missing leads were noted.

4.1.6 TQFP's

Most of the TQFP-144's and the TQFP-208's had broken and/or missing leads at the end of the test (see data in Appendices A and B and Figure 34). Since it appeared that most

of the recorded failures were due to lead failure rather than solder joint failure, no comparisons of solder performance could be made.

4.1.7 Plated Through Holes (PTH's)

No PTH failures were observed.

4.2 Observations (“Rework” Test Vehicles)

The “Rework” test vehicles were initially assembled with SnPb solder. During rework, the old component was removed; the pads were wicked clean of most but not all of the SnPb; and a new component was attached using a lead-free solder. Therefore, all solder joints on the “Rework” vehicles contain lead, even the components that were reworked (see Table 5). In addition, the effects of lead contamination and the effects (if any) of the heat of the rework operation upon the reliability of the solder joints in this test are not separable from each other.

For some components on the “Rework” boards, only SnPb solder was used and therefore no ranking of solders was possible. The test results for these components will not be discussed here but they can be found in Appendix D.

4.2.1 BGA-225’s

For BGA’s that were not reworked, SnPb balls assembled with SnPb paste always outperformed SnAgCu (SAC) balls assembled with SnPb paste.

For BGA’s that were reworked, SnPb balls assembled using flux only always outperformed SnAgCu (SAC) balls assembled using flux only. In the latter case, the final SAC solder joints contained approximately 0.3% Pb contamination.

4.2.2 CLCC-20’s

No CLCC’s were reworked. Assembly using SnPb solder paste and CLCC’s finished with either SnPb solder, SAC solder or SACB solder showed that SnPb solder paste combined with a SnPb part finish performed best. This is in contrast to the mixed solder data from the “Manufactured” CLCC’s where the combination of SACB paste/SnPb finish performed the best. The difference may be due to the fact that the “Rework” vehicles were assembled using a SnPb reflow profile which did not reflow the lead-free part finishes which in turn had an effect on joint reliability.

4.2.3 PDIP-20’s

For the PDIP’s that were reworked (U23 and U59, NiPdAu finish), SnPb solder was the best performer. This is in sharp contrast to the results from the “Manufactured” vehicles where the Sn0.7Cu0.05Ni wave solder alloy (combined with a NiPdAu part finish) was by far the best performer, followed by the SAC alloy and then SnPb. These results may

be partly due to the negative effect that small amounts of Pb have on the reliability of Sn0.7Cu (Reference 5). Chemical analysis of two reworked PDIP solder joints showed that the residual Pb contamination could vary (2.98% Pb vs. 0.38% Pb, Table 5). The amount of residual Pb in the PDIP joints was probably dependent upon how well the operator was able to remove residual SnPb solder from the plated through hole during rework.

In addition, PDIP U23 had some early failures with the SnCu and the SnPb solders that were not seen on the “Manufactured” test vehicles and that may be related to the rework operation.

4.2.4 TSOP-50’s

As with the “Manufactured” vehicles, the TSOP’s oriented parallel to the shorter side of the “Rework” test vehicle (U12, U16, U26, and U29) tended to fall off during the testing (see Table 9). The TSOP’s oriented perpendicular to the shorter side of the test vehicle (U24, U25, U39, and U40) did not fall off during the testing. The general failure mechanism for the TSOP’s was the same as discussed for the “Manufactured” test vehicles.

The performance ranking of solders for the TSOP’s that were reworked (U12 and U25) mirrored that observed for the corresponding TSOP’s on the “Manufactured” test vehicles. For example, with U12 (oriented parallel to the short test vehicle edge) the relative solder ranking was SnPb > SAC > SACB. However, for U25 (oriented perpendicular to the short vehicle edge) the relative solder ranking was SAC > SACB > SnPb.

Most of the TSOP’s on the “Rework” test vehicle were assembled using only SnPb solder. However, TSOP’s with a SnPb component finish were used on the “control” vehicles while a SnCu component finish was used on the balance of the test vehicles. The reader can find the test data comparing the two finishes in Appendix D. On average, there was no distinct difference between the SnPb and SnCu finishes when combined with SnPb solder.

4.2.5 TQFP’s

The TQFP-208’s that were reworked were U3 and U57. For U57, it appeared that most of the recorded failures were due to lead failure rather than solder joint failure meaning that no comparisons of solder performance could be made.

TQFP U3 was unusual in that 7 out of 15 components had electrical opens before the test began. At least two of the seven bad components failed during normal handling between the time the test vehicles were received at Boeing and the vibration test was started. In addition, 11 out of 15 U3’s fell off of the “Rework” vehicles during test (compared to 0 of 15 during testing of the “Manufactured” vehicles, see Table 7). Visual examination of the pads that had lost a component revealed that while some of the pads retained the stubs

of broken leads, many of the pads no longer had any significant solder on them (see Figure 35). TQFP U3 and the adjacent BGA's (U4 and U18) were removed at the same time during rework. It is believed that heat from the replacement of the BGA's prior to replacement of TQFP U3 affected the U3 pads resulting in a weak pad/solder interface. In contrast, the other TQFP that was reworked (U57) did not exhibit premature electrical failure during normal handling and did not come off of the vehicle during testing.

4.2.6 Plated Through Holes (PTH's)

No PTH failures were observed.

5.0 Summary

The results of the vibration testing are summarized in Tables 10 – 12. The solders were ranked according to which solder survived the longest with each component tested. The solder that survived the longest was assigned the number “1” and the color “green”. The next best solder was assigned a “2” and the color “yellow”. The solder that failed first was assigned the number “3” and the color “red”. In case of a tie, the two solders were assigned the same number and color. For those cases where it was not readily apparent which solder performed the best, Weibull plots of the data were used to help determine the ranking.

On the “Manufactured” test vehicles, the lead-free solders under test sometimes performed better than the eutectic tin/lead control. For example, Sn3.4Ag1.0Cu3.3Bi was the best performer with the ceramic leadless chip carriers (CLCC's) and Sn0.7Cu0.05Ni was the best performer with the PDIP's (with both NiPdAu and matte tin component finishes).

In some cases, the performance of the solders was mixed. For example, the orientation of the TSOP's may have played a role in how well the solders performed and in their relative ranking. With TSOP U12 (oriented parallel to the short vehicle edge) the relative solder ranking was SnPb > Sn3.9Ag0.6 Cu > Sn3.4Ag1.0Cu3.3Bi. However, for TSOP U25 (oriented perpendicular to the short vehicle edge) the relative solder ranking was Sn3.9Ag0.6 Cu > Sn3.4Ag1.0Cu3.3Bi > SnPb. These patterns were repeated for the same components on the “Rework” test vehicles which supports the hypothesis that there could be an orientation effect. For U29, both Sn3.9Ag0.6 Cu and Sn3.4Ag1.0Cu3.3Bi were superior to SnPb but there were not enough failures to rank the two lead-free solders.

In contrast, tin/lead solder outperformed the lead-free solders with the PLCC's. Only PLCC U15 exhibited failures, however, demonstrating that PLCC's are comparatively resistant to high vibration environments.

With the BGA's, the combination of eutectic SnPb solder/SnPb balls always outperformed the combination of lead-free solder with Sn4.0Ag0.5 Cu balls.

Contamination of the lead-free solders with Pb gave mixed results. For example, Sn3.4Ag1.0Cu3.3Bi was still the best performer with the ceramic leadless chip carriers (CLCC's) even when contaminated with large amounts of lead (approximately 17% Pb). With the BGA's, the combination of eutectic SnPb solder/SnPb balls outperformed lead-free solder/SnPb balls. The effects of Pb contamination on the reliability of the TSOP solder joints varied.

None of the TQFP data was useful for comparing solder performance since most of the TQFP failures appeared to be due to broken leads and not failed solder joints.

On the "Rework" test vehicles, SnPb generally outperformed the lead-free solders on those components that were reworked. For BGA's that were reworked, SnPb balls assembled using flux only always outperformed SnAgCu balls assembled using flux only. In the latter case, the final SnAgCu solder joints contained approximately 0.3% Pb contamination from the residual SnPb left on the pads after removal of the SnPb component. For the PDIP's that were reworked (U23 and U59, NiPdAu finish), SnPb solder was also the best performer. This is in sharp contrast to the results from the "Manufactured" vehicles where the Sn0.7Cu0.05Ni wave solder alloy was the best performer, followed by the SnAgCu alloy and then SnPb. These results may be partly due to the negative effect that small amounts of Pb have on the reliability of Sn0.7Cu (Reference 5).

The reworked TQFP U3 was unusual in that 7 out of 15 components had electrical opens before the test began. At least two of the seven bad components failed during normal handling between the time the test vehicles were received at Boeing and the vibration test was started. In addition, 11 out 15 U3's fell off of the "Rework" vehicles during test (compared to 0 of 15 during testing of the "Manufactured" vehicles, see Table 9). Visual examination of the pads that had lost a component revealed that many of the pads no longer had any significant solder on them (see Figure 3). TQFP U3 and the adjacent BGA's (U4 and U18) were removed at the same time during rework. It is believed that heat from the replacement of the BGA's prior to replacement of TQFP U3 affected the U3 pads resulting in a weak pad/solder interface. In contrast, the other TQFP that was reworked (U57) did not exhibit premature electrical failure during normal handling and did not come off of the vehicle during testing.

6.0 Conclusions and Recommendations

The results of this study suggest that for some component types, lead-free solders are as reliable as the currently used eutectic SnPb solder with respect to vibration.

Unfortunately, this study also demonstrated that with other component types, the lead-free solders failed before the Sn/Pb control. Although this does not mean that lead-free solders can not be used in high reliability electronics, it does imply that models for calculating the actual field lifetime of lead-free solder joints on certain component types will need to be developed and validated using actual vibration test data (from this and

other studies). These models can then be used to verify that electronics made with lead-free solders will survive for the required lifetime in the field.

Another area that needs to be addressed is the potential reliability problem with SnAgCu alloys used on area array devices. Texas Instruments and IBM (Reference 6) have shown that thermal aging of SnAgCu solder joints can significantly reduce their reliability under mechanical shock/vibration due to the formation of Kirkendall voids. None of the test vehicles in the current study were thermally aged in an effort to promote Kirkendall voiding. More work needs to be done to understand this phenomenon before adopting lead-free solders for use in high reliability electronics.

7.0 References

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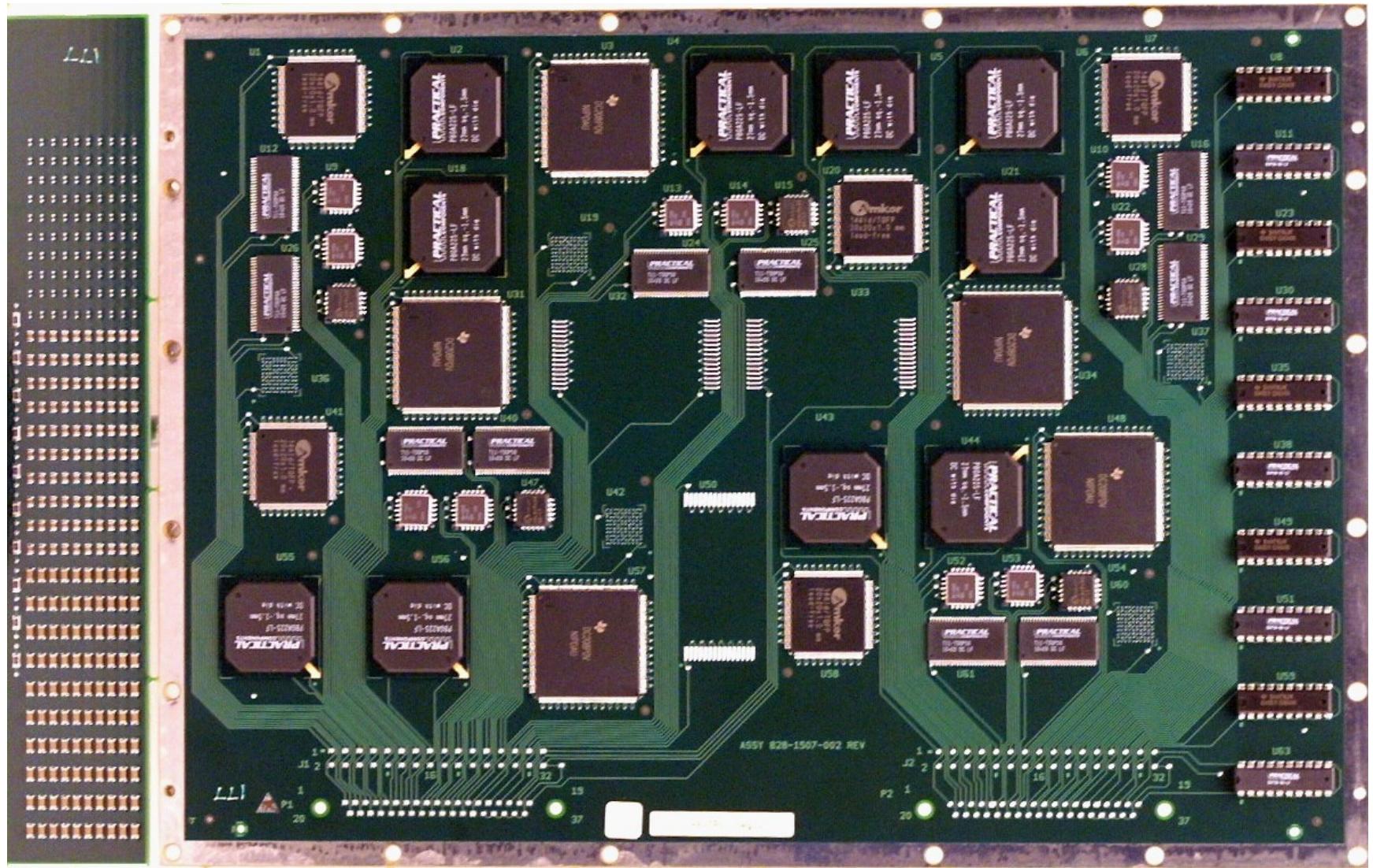


Figure 1. Test Vehicle with Break-Off Coupon Attached

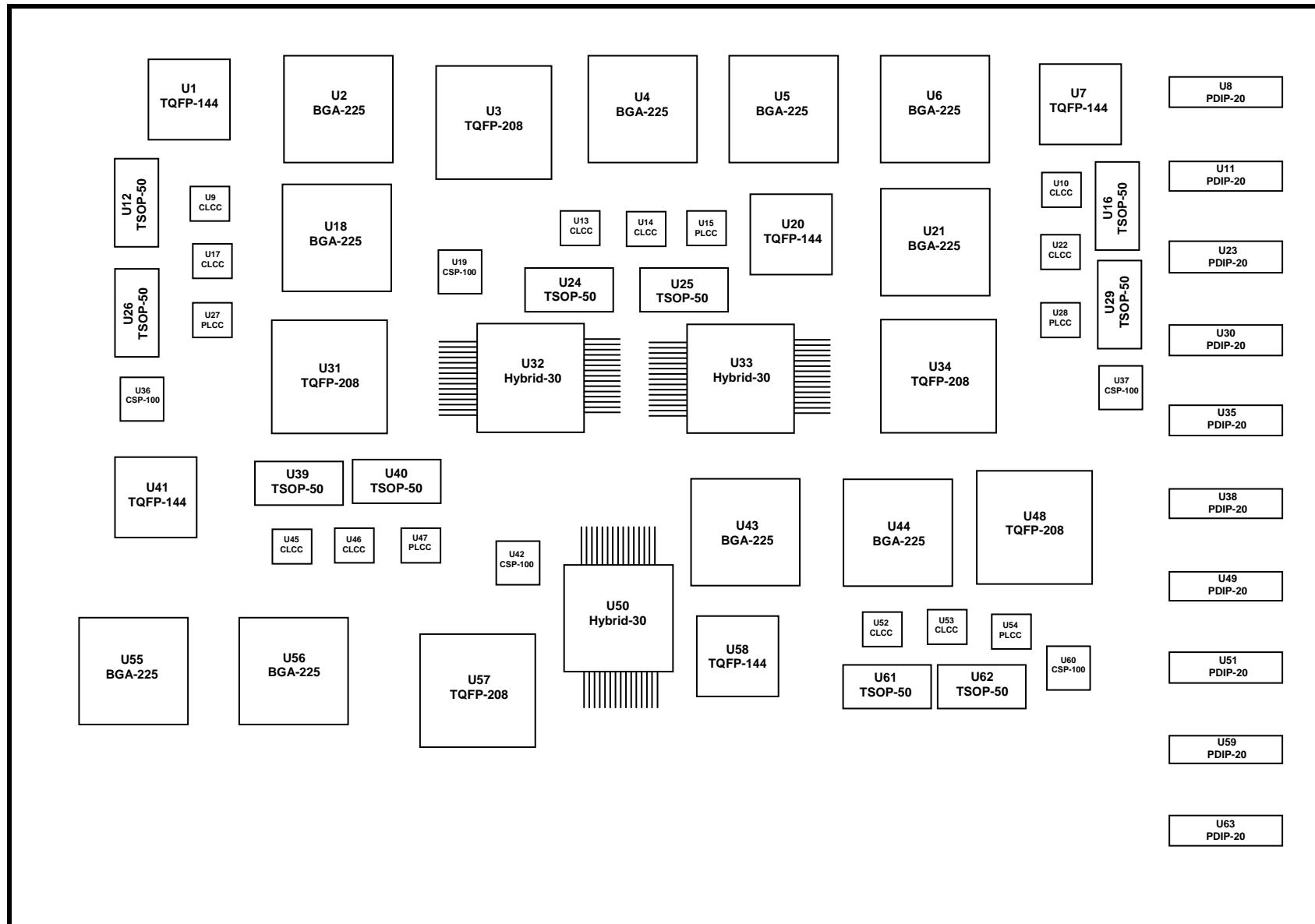


Figure 2. Main Test Vehicle Schematic

Table 1. Test Vehicle Key (“Manufactured” PWA’s – Controls)

Test Vehicle ID Numbers: 5 through 9

Reference Designator	Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)
U1	TQFP-144	Sn	SnPb	
U2	BGA-225	SnPb	SnPb	
U3	TQFP-208	NiPdAu	SnPb	
U4	BGA-225	SnPb	SnPb	
U5	BGA-225	SnPb	SnPb	
U6	BGA-225	SnPb	SnPb	
U7	TQFP-144	Sn	SnPb	
U8	PDIP-20	NiPdAu		SnPb
U9	CLCC-20	SnPb	SnPb	
U10	CLCC-20	SnPb	SnPb	
U11	PDIP-20	Sn		SnPb
U12	TSOP-50	SnPb	SnPb	
U13	CLCC-20	SnPb	SnPb	
U14	CLCC-20	SnPb	SnPb	
U15	PLCC-20	Sn	SnPb	
U16	TSOP-50	SnPb	SnPb	
U17	CLCC-20	SnPb	SnPb	
U18	BGA-225	SnPb	SnPb	
U19	CSP-100	SnPb	SnPb	
U20	TQFP-144	Sn	SnPb	
U21	BGA-225	SnPb	SnPb	
U22	CLCC-20	SnPb	SnPb	
U23	PDIP-20	NiPdAu		SnPb
U24	TSOP-50	SnPb	SnPb	
U25	TSOP-50	SnPb	SnPb	
U26	TSOP-50	SnPb	SnPb	
U27	PLCC-20	Sn	SnPb	
U28	PLCC-20	Sn	SnPb	
U29	TSOP-50	SnPb	SnPb	
U30	PDIP-20	Sn		SnPb
U31	TQFP-208	NiPdAu	SnPb	
U32	Hybrid-30	SnPb	SnPb	
U33	Hybrid-30	SnPb	SnPb	
U34	TQFP-208	NiPdAu	SnPb	
U35	PDIP-20	NiPdAu		SnPb
U36	CSP-100	SnPb	SnPb	
U37	CSP-100	SnPb	SnPb	
U38	PDIP-20	Sn		SnPb
U39	TSOP-50	SnPb	SnPb	
U40	TSOP-50	SnPb	SnPb	
U41	TQFP-144	Sn	SnPb	
U42	CSP-100	SnPb	SnPb	
U43	BGA-225	SnPb	SnPb	
U44	BGA-225	SnPb	SnPb	
U45	CLCC-20	SnPb	SnPb	
U46	CLCC-20	SnPb	SnPb	
U47	PLCC-20	Sn	SnPb	
U48	TQFP-208	NiPdAu	SnPb	
U49	PDIP-20	NiPdAu		SnPb
U50	Hybrid-30	SnPb	SnPb	
U51	PDIP-20	Sn		SnPb
U52	CLCC-20	SnPb	SnPb	
U53	CLCC-20	SnPb	SnPb	
U54	PLCC-20	Sn	SnPb	
U55	BGA-225	SnPb	SnPb	
U56	BGA-225	SnPb	SnPb	
U57	TQFP-208	NiPdAu	SnPb	
U58	TQFP-144	Sn	SnPb	
U59	PDIP-20	NiPdAu		SnPb
U60	CSP-100	SnPb	SnPb	
U61	TSOP-50	SnPb	SnPb	
U62	TSOP-50	SnPb	SnPb	
U63	PDIP-20	Sn		SnPb

Hybrids and CSPs were left off of the test vehicles.

Table 2. Test Vehicle Key (“Manufactured” PWA’s)

Reference Designator	Component	Test Vehicle ID Numbers: 75 through 79			Test Vehicle ID Numbers: 114 through 118		
		Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)	Component Finish	Reflow Solder Alloy	Wave Solder Alloy (DIP's only)
U1	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U2	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U3	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U4	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U5	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U6	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U7	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U8	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U9	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U10	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U11	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U12	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U13	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U14	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U15	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U16	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U17	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U18	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U19	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U20	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U21	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U22	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U23	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U24	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U25	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U26	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U27	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U28	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U29	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U30	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U31	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U32	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U33	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U34	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U35	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U36	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U37	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U38	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U39	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U40	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U41	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U42	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U43	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U44	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U45	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U46	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U47	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U48	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U49	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U50	Hybrid-30	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U51	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni
U52	CLCC-20	Sn3.9Ag0.6Cu	Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	Sn3.4Ag1Cu3.3Bi	
U53	CLCC-20	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U54	PLCC-20	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U55	BGA-225	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U56	BGA-225	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U57	TQFP-208	NiPdAu	Sn3.9Ag0.6Cu		NiPdAu	Sn3.4Ag1Cu3.3Bi	
U58	TQFP-144	Sn	Sn3.9Ag0.6Cu		Sn	Sn3.4Ag1Cu3.3Bi	
U59	PDIP-20	NiPdAu		Sn3.9Ag0.6Cu	NiPdAu		Sn0.7Cu0.05Ni
U60	CSP-100	SnAgCu	Sn3.9Ag0.6Cu		SnAgCu	Sn3.4Ag1Cu3.3Bi	
U61	TSOP-50	SnCu	Sn3.9Ag0.6Cu		SnCu	Sn3.4Ag1Cu3.3Bi	
U62	TSOP-50	SnPb	Sn3.9Ag0.6Cu		SnPb	Sn3.4Ag1Cu3.3Bi	
U63	PDIP-20	Sn		Sn3.9Ag0.6Cu	Sn		Sn0.7Cu0.05Ni

Hybrids and CSPs were left off of the test vehicles.

SnAgCu BGA balls were Sn4.0Ag0.5Cu.

Table 3. Test Vehicle Key (“Rework” PWA’s – Controls)

Test Vehicle ID Numbers: 43, 46, 47, 49, 50

Reference Designator	Component	Component Finish (Before Rework)	Reflow Solder Alloy (Before Rework)	Wave Solder Alloy (Before Rework)	Component Finish (After Rework)	Rework Solder Alloy
U1	TQFP-144	Sn	SnPb			
U2	BGA-225	SnPb	SnPb			
U3	TQFP-208	NiPdAu	SnPb		NiPdAu	SnPb
U4	BGA-225	SnPb	SnPb		SnPb	SnPb
U5	BGA-225	SnPb	SnPb			
U6	BGA-225	SnPb	SnPb			
U7	TQFP-144	Sn	SnPb			
U8	PDIP-20	NiPdAu		SnPb		
U9	CLCC-20	SnPb	SnPb			
U10	CLCC-20	SnPb	SnPb			
U11	PDIP-20	Sn		SnPb		
U12	TSOP-50	SnPb	SnPb		SnPb	SnPb
U13	CLCC-20	SnPb	SnPb			
U14	CLCC-20	SnPb	SnPb			
U15	PLCC-20	Sn	SnPb			
U16	TSOP-50	SnPb	SnPb			
U17	CLCC-20	SnPb	SnPb			
U18	BGA-225	SnPb	SnPb		SnPb	SnPb
U19	CSP-100	SnPb	SnPb			
U20	TQFP-144	Sn	SnPb			
U21	BGA-225	SnPb	SnPb			
U22	CLCC-20	SnPb	SnPb			
U23	PDIP-20	NiPdAu		SnPb	NiPdAu	SnPb
U24	TSOP-50	SnPb	SnPb			
U25	TSOP-50	SnPb	SnPb		SnPb	SnPb
U26	TSOP-50	SnPb	SnPb			
U27	PLCC-20	Sn	SnPb			
U28	PLCC-20	Sn	SnPb			
U29	TSOP-50	SnPb	SnPb			
U30	PDIP-20	Sn		SnPb		
U31	TQFP-208	NiPdAu	SnPb			
U32	Hybrid-30	SnPb	SnPb			
U33	Hybrid-30	SnPb	SnPb			
U34	TQFP-208	NiPdAu	SnPb			
U35	PDIP-20	NiPdAu		SnPb		
U36	CSP-100	SnPb	SnPb			
U37	CSP-100	SnPb	SnPb			
U38	PDIP-20	Sn		SnPb		
U39	TSOP-50	SnPb	SnPb			
U40	TSOP-50	SnPb	SnPb			
U41	TQFP-144	Sn	SnPb			
U42	CSP-100	SnPb	SnPb			
U43	BGA-225	SnPb	SnPb			
U44	BGA-225	SnPb	SnPb			
U45	CLCC-20	SnPb	SnPb			
U46	CLCC-20	SnPb	SnPb			
U47	PLCC-20	Sn	SnPb			
U48	TQFP-208	NiPdAu	SnPb			
U49	PDIP-20	NiPdAu		SnPb		
U50	Hybrid-30	SnPb	SnPb			
U51	PDIP-20	Sn		SnPb		
U52	CLCC-20	SnPb	SnPb			
U53	CLCC-20	SnPb	SnPb			
U54	PLCC-20	Sn	SnPb			
U55	BGA-225	SnPb	SnPb			
U56	BGA-225	SnPb	SnPb			
U57	TQFP-208	NiPdAu	SnPb		NiPdAu	SnPb
U58	TQFP-144	Sn	SnPb			
U59	PDIP-20	NiPdAu		SnPb	NiPdAu	SnPb
U60	CSP-100	SnPb	SnPb			
U61	TSOP-50	SnPb	SnPb			
U62	TSOP-50	SnPb	SnPb			
U63	PDIP-20	Sn		SnPb		

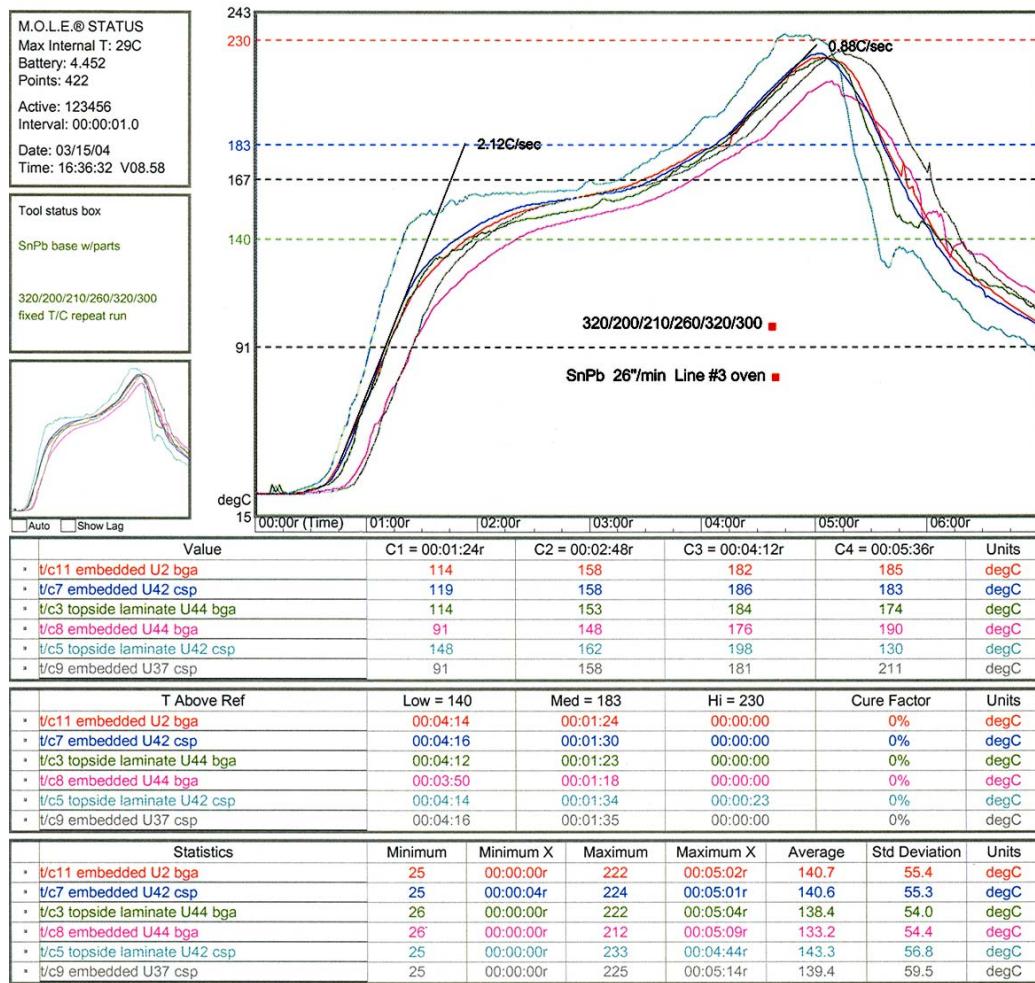
Reworked components are shown in red.
Hybrids and CSPs were left off of the test vehicles.

Table 4. Test Vehicle Key (“Rework” PWA’s)

Rework PWAs

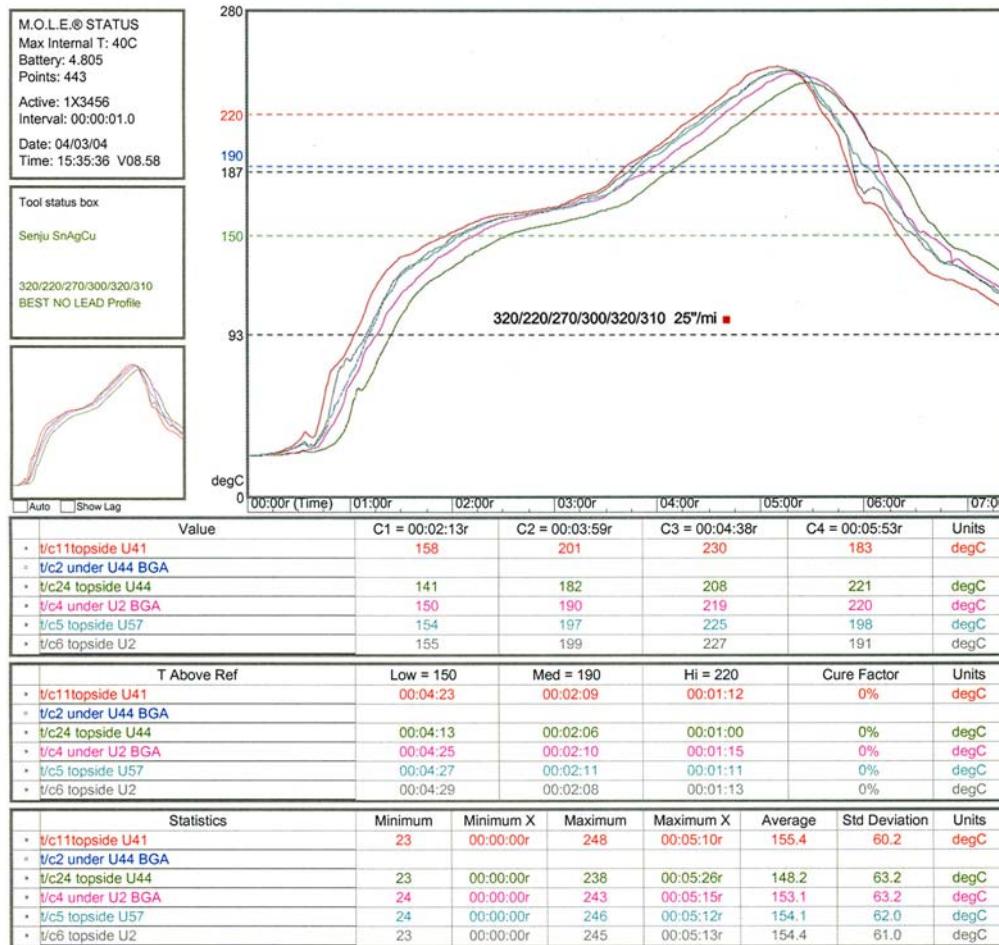
Reference Designator	Component	Test Vehicle ID Numbers: 153 through 157			Test Vehicle ID Numbers: 180, 182 through 185		
		Reflow Solder Alloy (Before Rework)	Wave Solder Alloy (Before Rework)	Component Finish (Before Rework)	Component Finish (After Rework)	Rework Solder Alloy	Component Finish (Before Rework)
U1	TQFP-144	SnPb		Sn		Sn	
U2	BGA-225	SnPb		SnAgCu		SnAgCu	
U3	TQFP-208	SnPb		NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu
U4	BGA-225	SnPb		SnPb	SnAgCu	flux only	SnPb
U5	BGA-225	SnPb		SnAgCu		SnAgCu	SnAgCu
U6	BGA-225	SnPb		SnAgCu		SnAgCu	
U7	TQFP-144	SnPb		Sn		Sn	
U8	PDIP-20		SnPb	NiPdAu		NiPdAu	
U9	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U10	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U11	PDIP-20		SnPb	Sn		Sn	
U12	TSOP-50	SnPb		SnPb	SnCu	Sn3.9Ag0.6Cu	SnCu
U13	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U14	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U15	PLCC-20	SnPb		Sn		Sn	
U16	TSOP-50	SnPb		SnCu		SnCu	
U17	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U18	BGA-225	SnPb		SnPb	SnAgCu	flux only	SnPb
U19	CSP-100	SnPb		SnAgCu		SnAgCu	
U20	TQFP-144	SnPb		Sn		Sn	
U21	BGA-225	SnPb		SnAgCu		SnAgCu	
U22	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U23	PDIP-20		SnPb	NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu
U24	TSOP-50	SnPb		SnCu		SnCu	
U25	TSOP-50	SnPb		SnPb	SnCu	Sn3.9Ag0.6Cu	SnPb
U26	TSOP-50	SnPb		SnCu		SnCu	
U27	PLCC-20	SnPb		Sn		Sn	
U28	PLCC-20	SnPb		Sn		Sn	
U29	TSOP-50	SnPb		SnCu		SnCu	
U30	PDIP-20		SnPb	Sn		Sn	
U31	TQFP-208	SnPb		NiPdAu		NiPdAu	
U32	Hybrid-30	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U33	Hybrid-30	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U34	TQFP-208	SnPb		NiPdAu		NiPdAu	
U35	PDIP-20		SnPb	NiPdAu		NiPdAu	
U36	CSP-100	SnPb		SnAgCu		SnAgCu	
U37	CSP-100	SnPb		SnAgCu		SnAgCu	
U38	PDIP-20		SnPb	Sn		Sn	
U39	TSOP-50	SnPb		SnCu		SnCu	
U40	TSOP-50	SnPb		SnCu		SnCu	
U41	TQFP-144	SnPb		Sn		Sn	
U42	CSP-100	SnPb		SnAgCu		SnAgCu	
U43	BGA-225	SnPb		SnAgCu		SnAgCu	
U44	BGA-225	SnPb		SnAgCu		SnAgCu	
U45	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U46	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U47	PLCC-20	SnPb		Sn		Sn	
U48	TQFP-208	SnPb		NiPdAu		NiPdAu	
U49	PDIP-20		SnPb	NiPdAu		NiPdAu	
U50	Hybrid-30	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U51	PDIP-20		SnPb	Sn		Sn	
U52	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U53	CLCC-20	SnPb		Sn3.9Ag0.6Cu		Sn3.4Ag1Cu3.3Bi	
U54	PLCC-20	SnPb		Sn		Sn	
U55	BGA-225	SnPb		SnAgCu		SnAgCu	
U56	BGA-225	SnPb		SnAgCu		SnAgCu	
U57	TQFP-208	SnPb		NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu
U58	TQFP-144	SnPb		Sn		Sn	
U59	PDIP-20		SnPb	NiPdAu	NiPdAu	Sn3.9Ag0.6Cu	NiPdAu
U60	CSP-100	SnPb		SnAgCu		SnAgCu	
U61	TSOP-50	SnPb		SnCu		SnCu	
U62	TSOP-50	SnPb		SnCu		SnCu	
U63	PDIP-20		SnPb	Sn		Sn	

Reworked components are shown in red. Hybrids and CSPs were left off of the test vehicles. SnAgCu BGA balls were Sn4.0Ag0.5Cu.



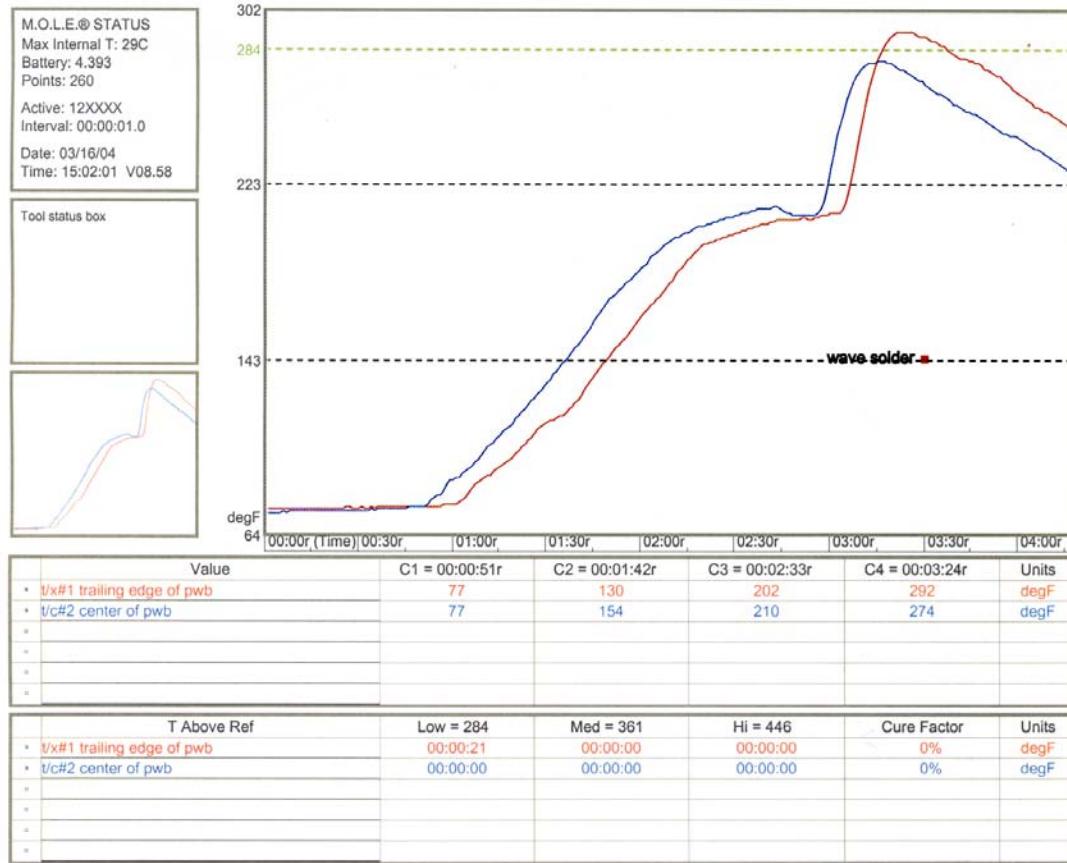
Preheat = ~ 120 seconds @ 140-183°C
Peak temperature target = 225°C
Reflow target:
60-90 sec above 183°C
Ramp Rate = 2-3 °C/sec

Figure 3. Reflow Profile for SnPb Solder Paste



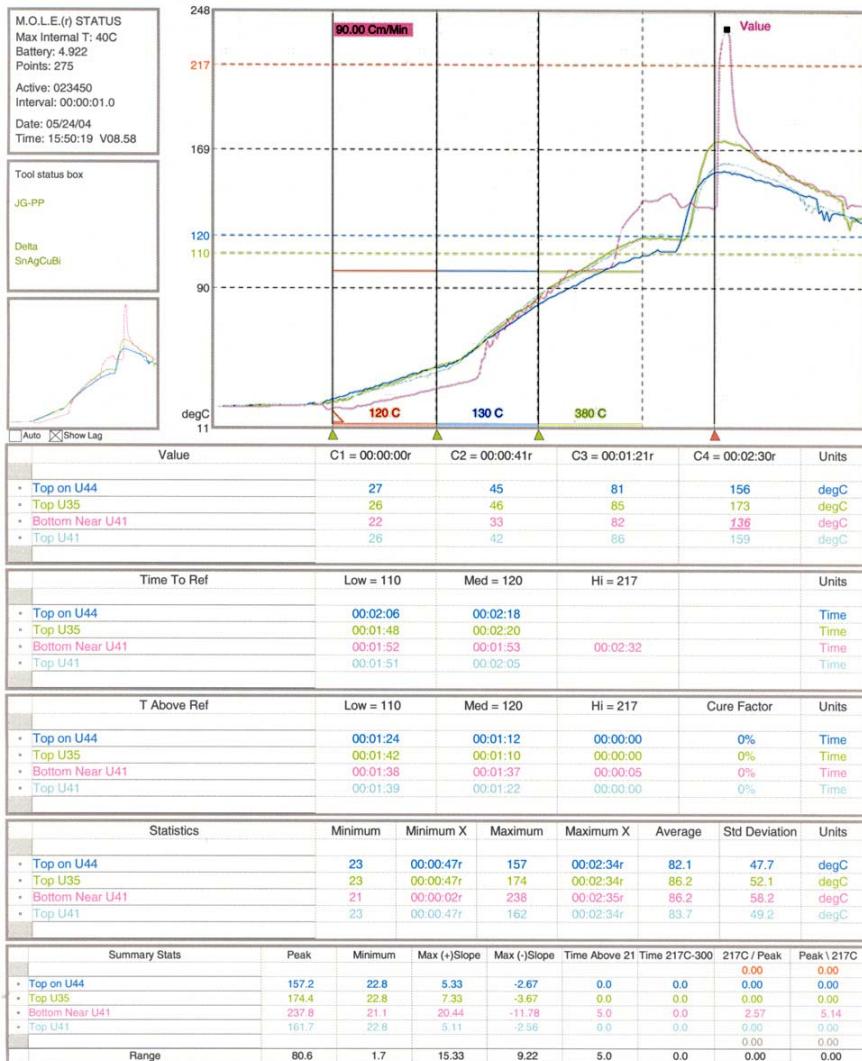
Preheat = 60-120 seconds @ 150-190°C
Peak temperature target = 243°C
Reflow target:
~30-90 seconds above 220°C

Figure 4. Reflow Profile for SnAgCu and SnAgCuBi Solder Pastes



Solder Pot Temperature = 250°C
Peak Board Temp. (Top) = 144°C
Conveyor Speed: 110 cm/min

Figure 5. Wave Soldering Profile for SnPb Solder



For SnCu:
Solder Pot Temperature = 265°C
Peak Board Temp. (Top) = 157°C
Conveyor Speed: 90 cm/min

For SnAgCu:
Solder Pot Temperature = 260°C
Peak Board Temp. (Top) = 161°C
Conveyor Speed: 90 cm/min

Figure 6. Wave Soldering Profile for SnCu and SnAgCu Solders

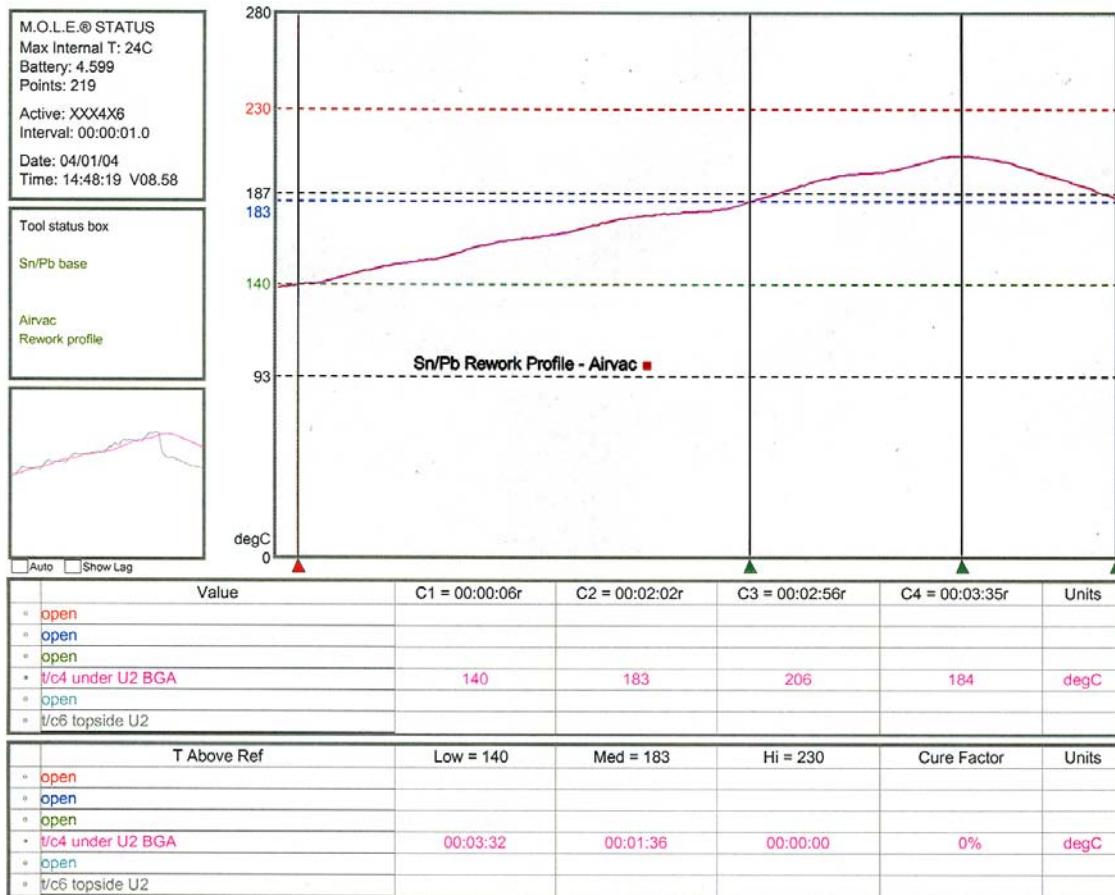
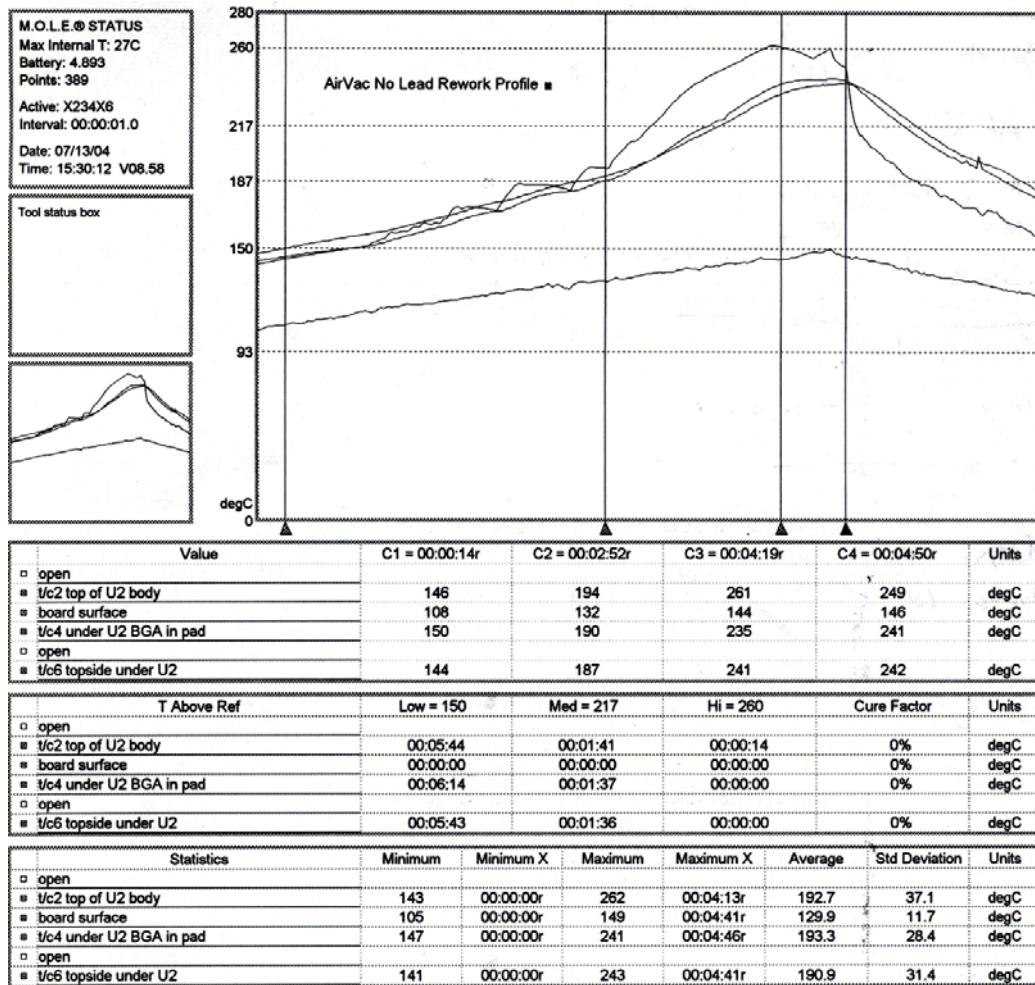


Figure 7. Air-Vac Rework Profile for SnPb Solder (BGA Removal and Replacement)



BGA ball target temp. = 243°C
 BGA top max target temp. = 260°C
 Board max temp. = 150°C
 Reflow targets:
 ~97 seconds above 217°C
 ~75 seconds above 221°C
 ~44 seconds above 235°C
 Ramp rate 1.14°C/sec

Figure 8. Air-Vac Rework Profile for Lead-Free Solders (BGA Removal and Replacement)

Table 5. Chemical Analysis of Solder Joints Contaminated with Pb (by ICP Spectroscopy)

Component	Ref. Des.	Test Vehicle ID	Reworked?	Component Finish	Board Finish	Solder	%Ag	%Cu	%Pb	%Sn	%Bi	%Au
CLCC	U9	80	no	SnPb	Ag	Sn3.9Ag0.6Cu	2.50	0.72	16.48	80.04	0.05	0.21
CLCC	U9	119	no	SnPb	Ag	Sn3.4Ag1.0Cu3.3Bi	2.23	0.82	16.76	78.07	1.94	0.18
CLCC	U9	158	no	Sn3.9Ag0.6Cu	SnPb	SnPb	1.52	0.62	22.72	75.11	0	0.03
CLCC	U9	186	no	Sn3.4Ag1.0Cu3.3Bi	SnPb	SnPb	1.32	0.57	22.93	73.86	1.30	0.02
TSOP	U26	80	no	SnPb	Ag	Sn3.9Ag0.6Cu	3.67	1.12	2.84	92.36	0.01	0
TSOP	U26	119	no	SnPb	Ag	Sn3.4Ag1.0Cu3.3Bi	3.16	1.98	3.05	89.01	2.80	0
TSOP	U12	158	yes	SnCu	Residual SnPb	Sn3.9Ag0.6Cu	3.31	2.12	0.86	93.71	0	0
TSOP	U12	186	yes	SnCu	Residual SnPb	Sn3.4Ag1.0Cu3.3Bi	2.89	1.98	1.06	91.52	2.55	0
BGA	U55	158	no	Sn4.0Ag0.5Cu	SnPb	SnPb	3.42	0.70	4.37	91.33	0	0.18
BGA	U4	158	yes	Sn4.0Ag0.5Cu	Residual SnPb	Flux Only	3.86	0.88	0.31	94.69	0	0.26
BGA	U4	186	yes	Sn4.0Ag0.5Cu	Residual SnPb	Flux Only	3.81	0.99	0.30	94.66	0	0.24
PDIP	U59	158	yes	NiPdAu	Residual SnPb	Sn3.9Ag0.6Cu	3.50	0.99	2.98	92.53	0	0
PDIP	U59	186	yes	NiPdAu	Residual SnPb	Sn0.7Cu0.05Ni	0	1.04	0.38	98.58	0	0
QFP-208	U3	158	yes	NiPdAu	Residual SnPb	Sn3.9Ag0.6Cu	3.34	6.63*	1.13	88.89	<0.05	<0.05

* Copper may have been removed from pads when solder joints were cut from vehicle

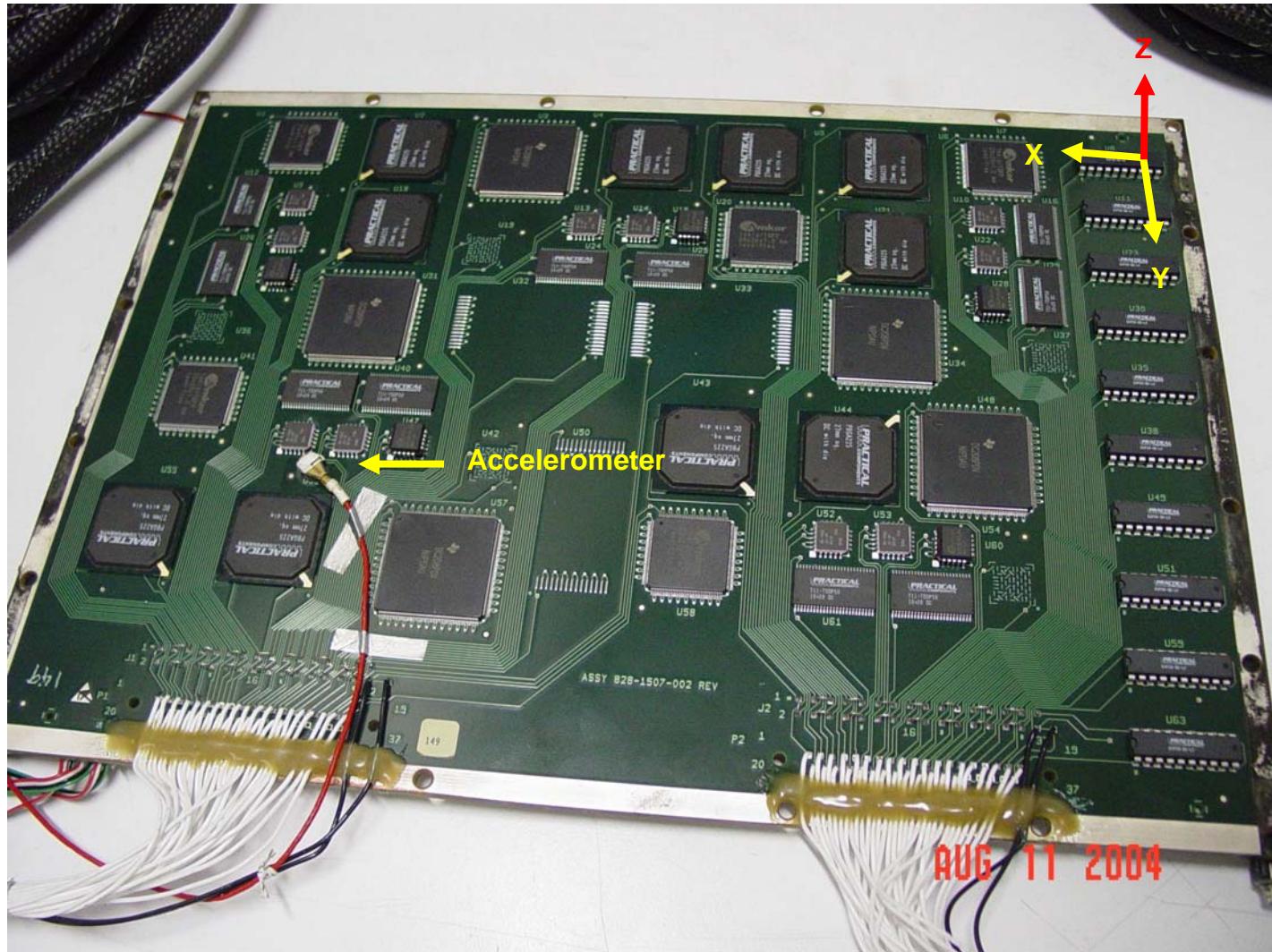


Figure 9. “Pathfinder” PWA showing Accelerometer Placement

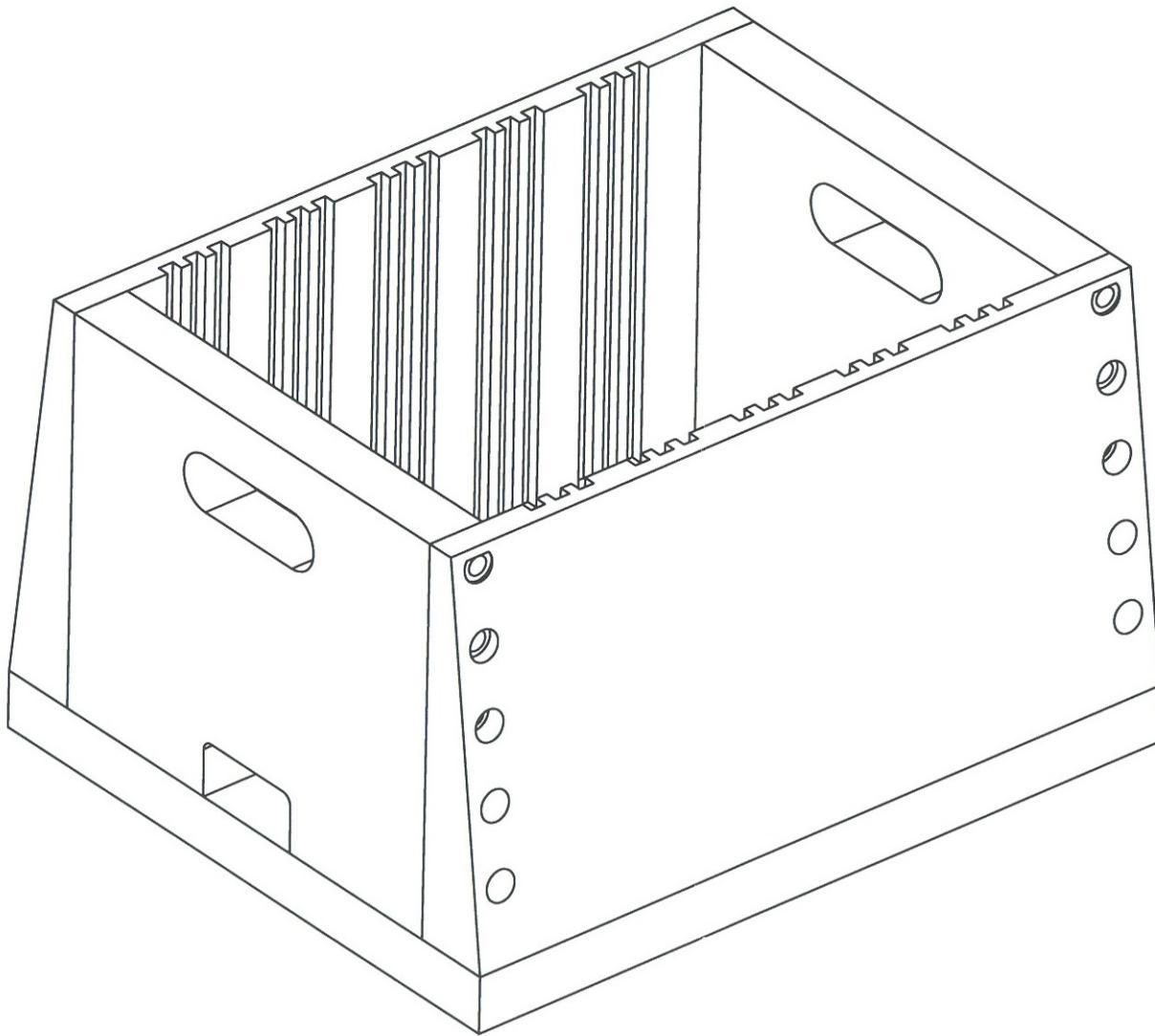


Figure 10. Fixture for Holding Test Vehicles

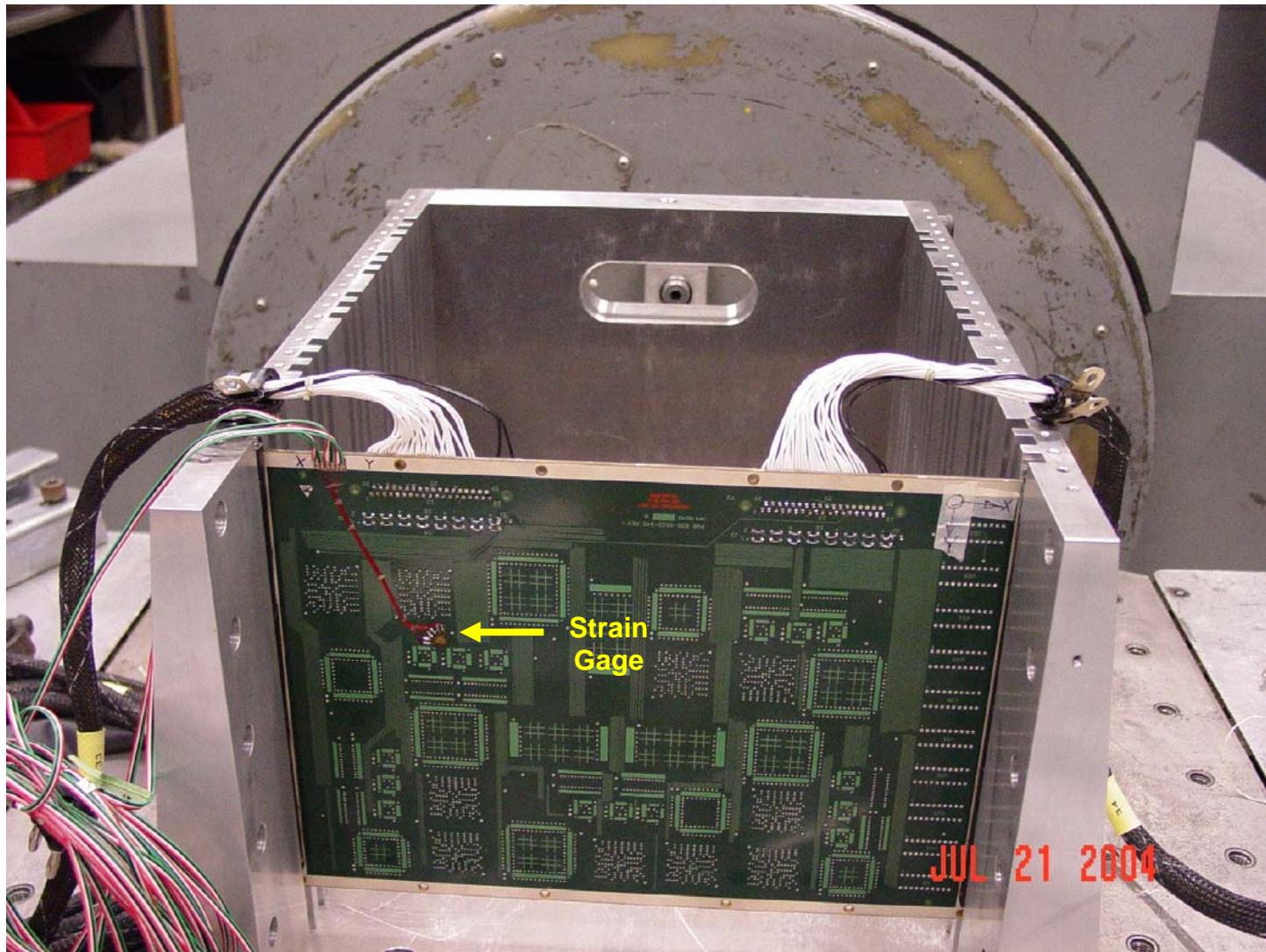


Figure 11. "Pathfinder" PWA showing Strain Gage Placement



Figure 12. Laser Vibrometer

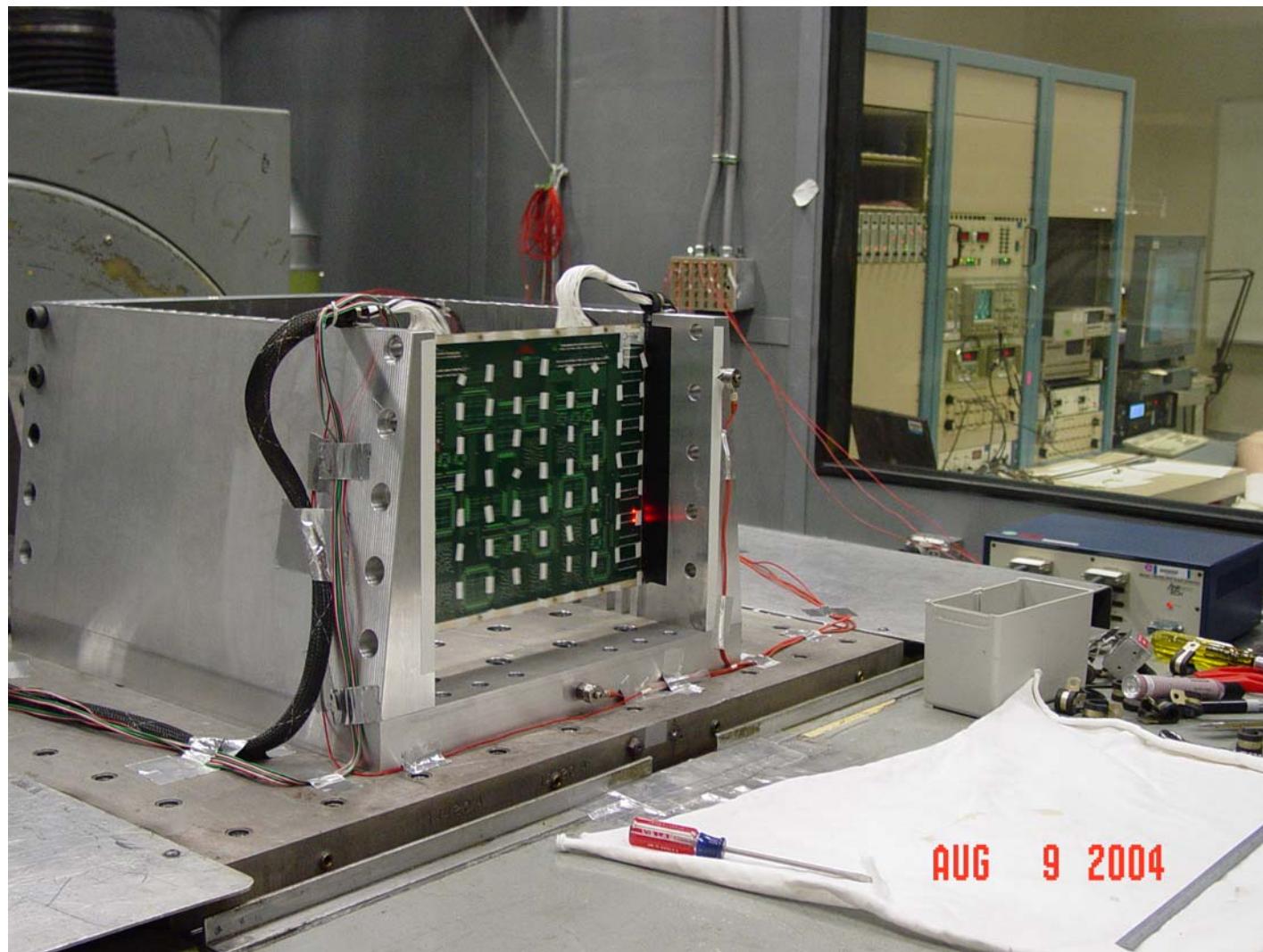


Figure 13. Laser Vibrometer Scanning “Pathfinder” PWA

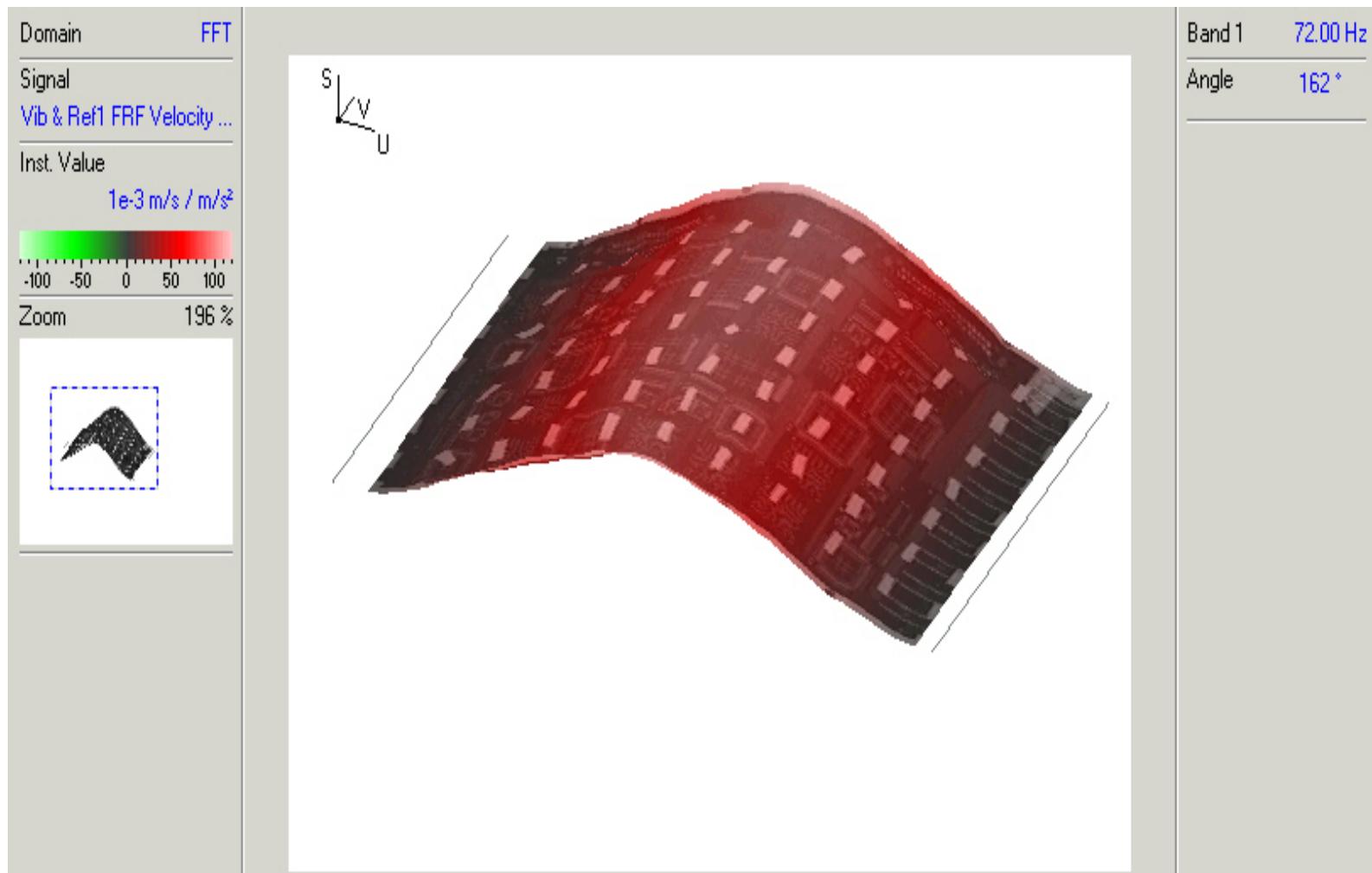


Figure 14. Operating Deflection Shape at 72 Hz ("Pathfinder" PWA)

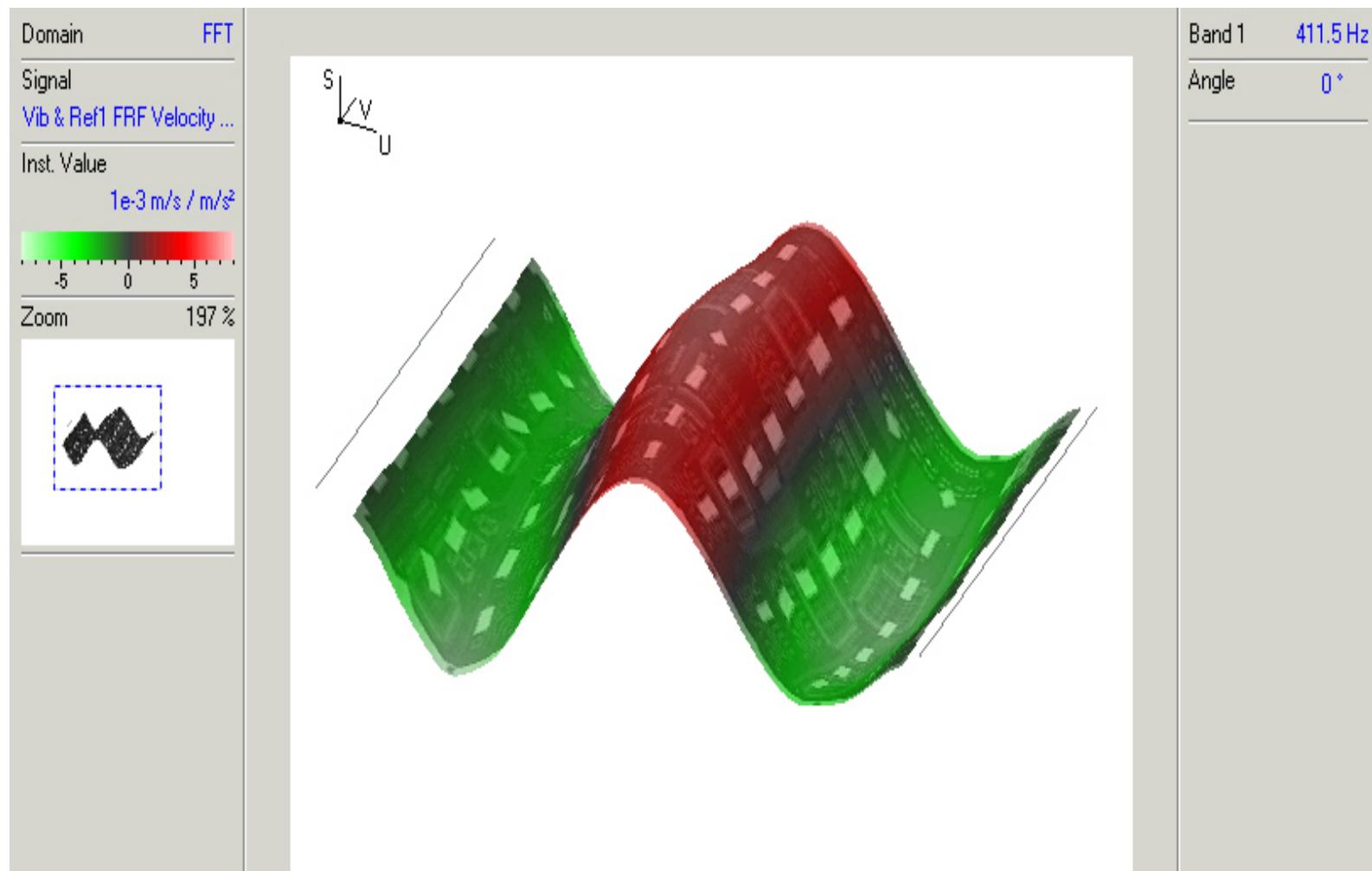


Figure 15. Operating Deflection Shape at 411 Hz (“Pathfinder” PWA)

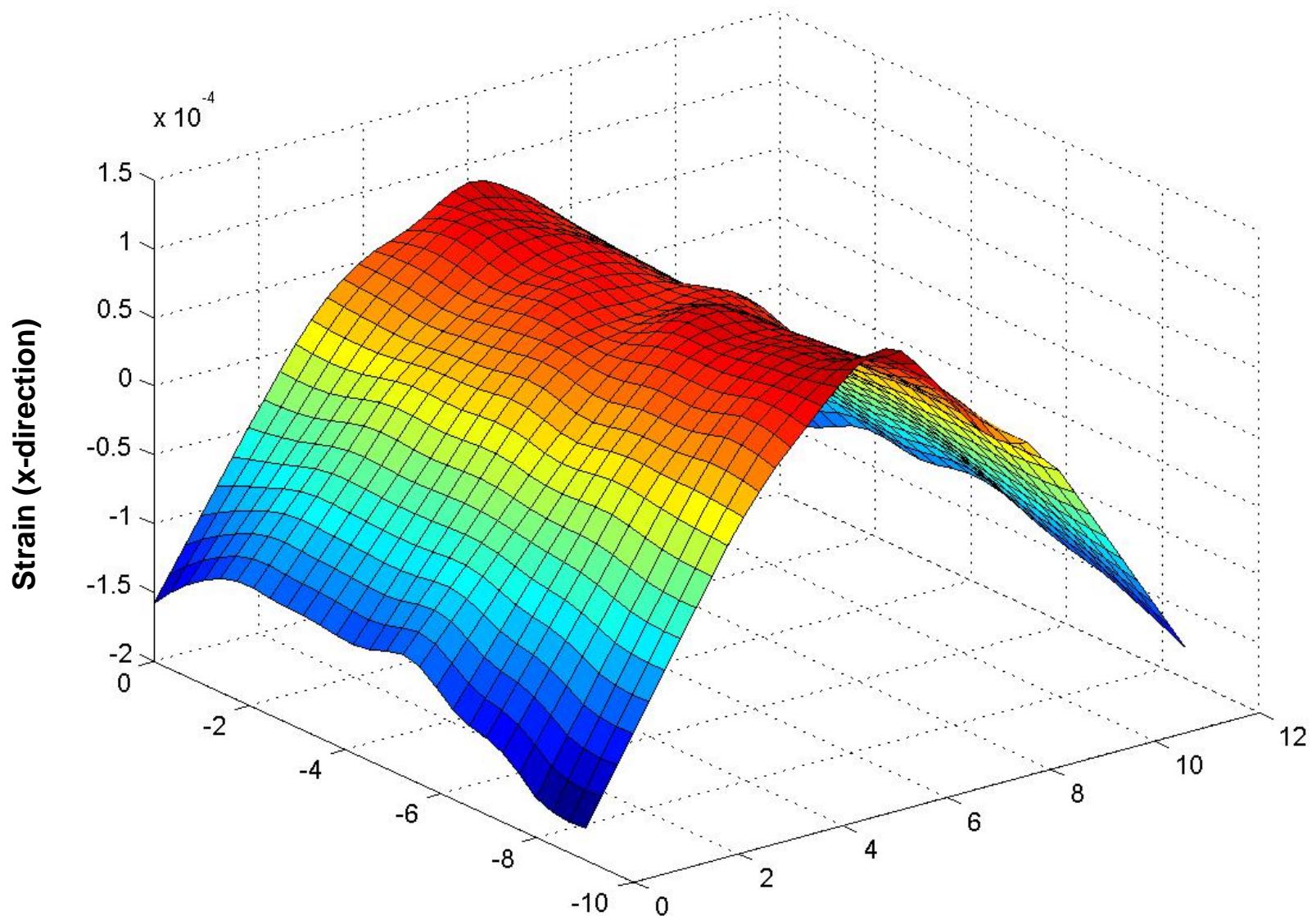


Figure 16. Full Field Peak Strains at 72 Hz (1 G Sine Dwell, “Pathfinder” PWA)

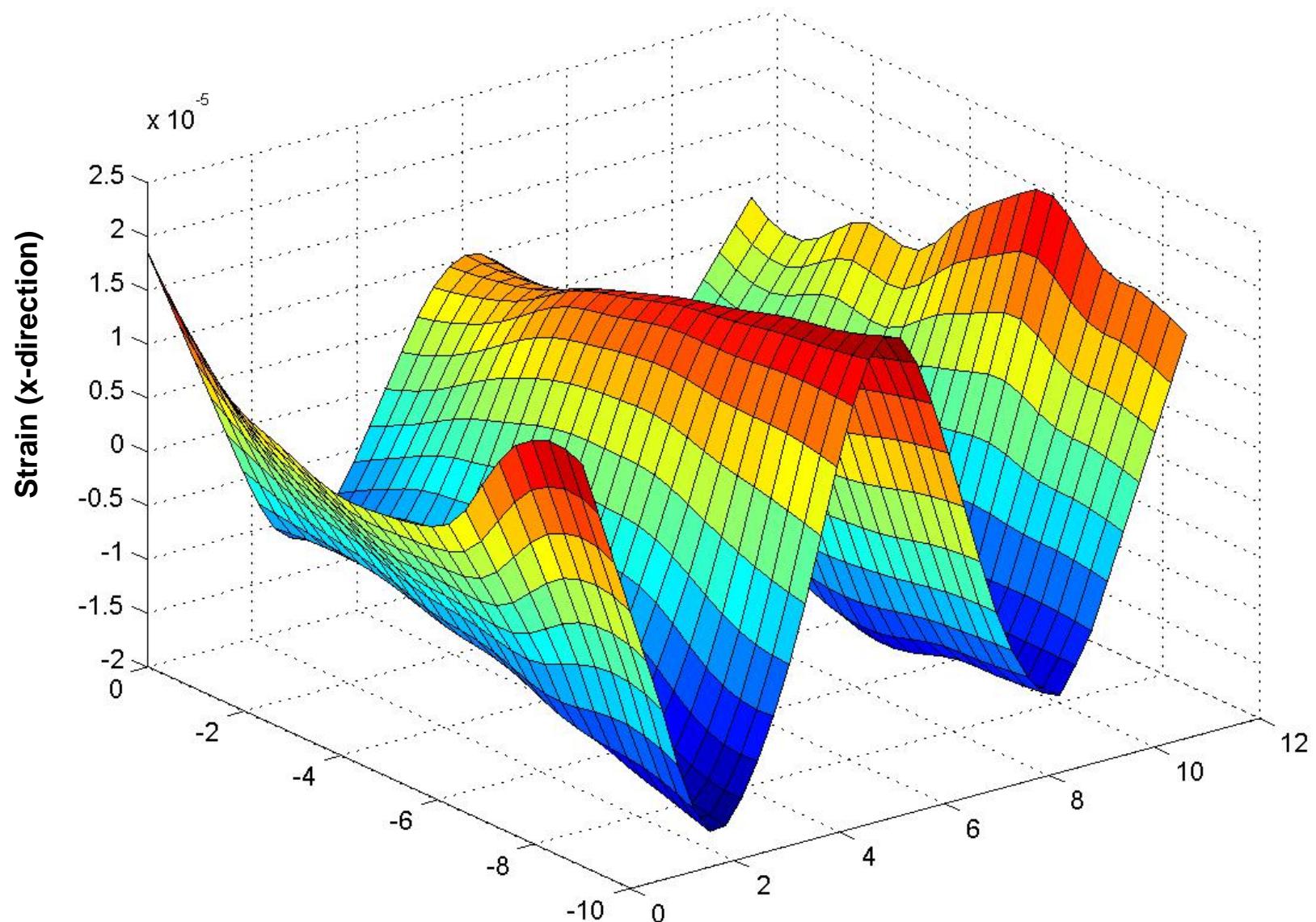


Figure 17. Full Field Peak Strains at 411 Hz (1 G Sine Dwell, “Pathfinder” PWA)

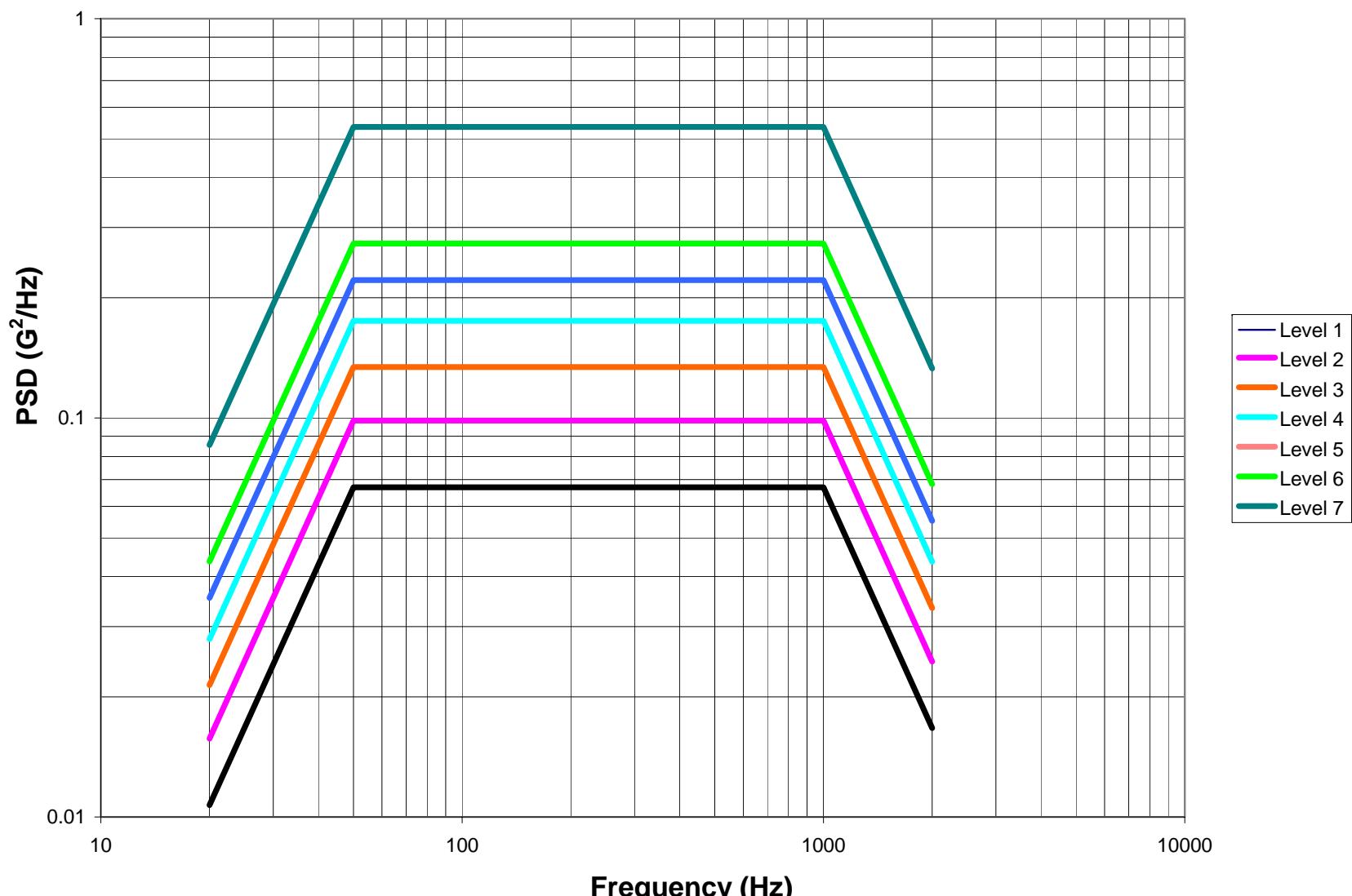


Figure 18. Vibration Test Levels

Table 6. Vibration Test Levels

Level 1	Level 2	Level 3
20 Hz @ 0.0107 G ² /Hz	20 Hz @ 0.0157 G ² /Hz	20 Hz @ 0.0214 G ² /Hz
20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.067 G ² /Hz	50 - 1000 Hz @ 0.0984 G ² /Hz	50 - 1000 Hz @ 0.134 G ² /Hz
1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.0167 G ² /Hz	2000 Hz @ 0.0245 G ² /Hz	2000 Hz @ 0.0334 G ² /Hz
Composite = 9.9 G_{rms}	Composite = 12.0 G_{rms}	Composite = 14.0 G_{rms}

Level 4	Level 5	Level 6
20 Hz @ 0.0279 G ² /Hz	20 Hz @ 0.0354 G ² /Hz	20 Hz @ 0.0437 G ² /Hz
20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave	20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.175 G ² /Hz	50 - 1000 Hz @ 0.2215 G ² /Hz	50 - 1000 Hz @ 0.2734 G ² /Hz
1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave	1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.0436 G ² /Hz	2000 Hz @ 0.0552 G ² /Hz	2000 Hz @ 0.0682 G ² /Hz
Composite = 16.0 G_{rms}	Composite = 18.0 G_{rms}	Composite = 20.0 G_{rms}

Level 7
20 Hz @ 0.0855 G ² /Hz
20 - 50 Hz @ +6.0 dB/octave
50 - 1000 Hz @ 0.5360 G ² /Hz
1000 - 2000 Hz @ -6.0 dB/octave
2000 Hz @ 0.1330 G ² /Hz
Composite = 28.0 G_{rms}

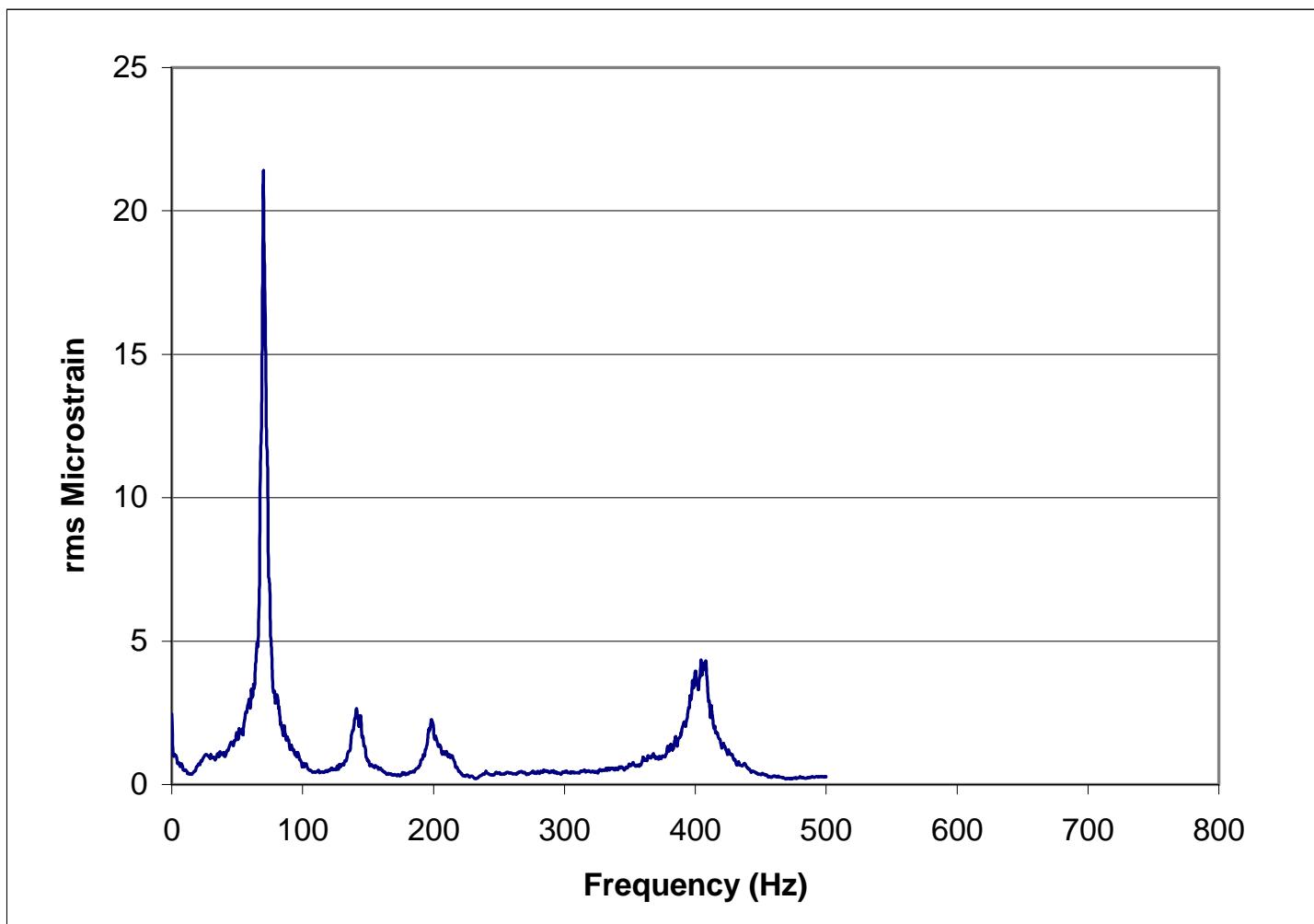


Figure 19. Strain vs. Frequency (from “Pathfinder” PWA Strain Gage at 9.9 Grms)

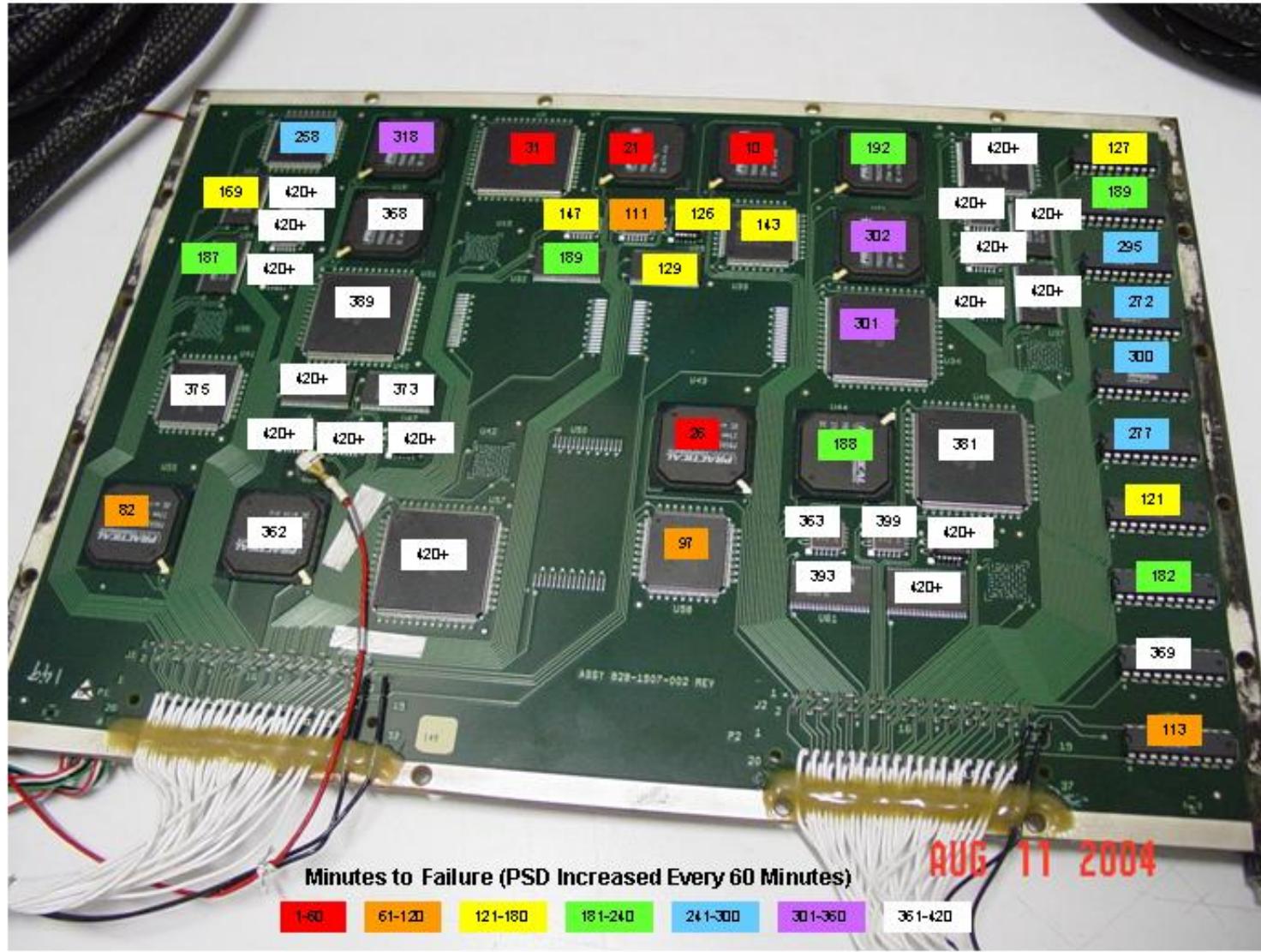


Figure 20. Times to Failure (“Pathfinder” PWA)

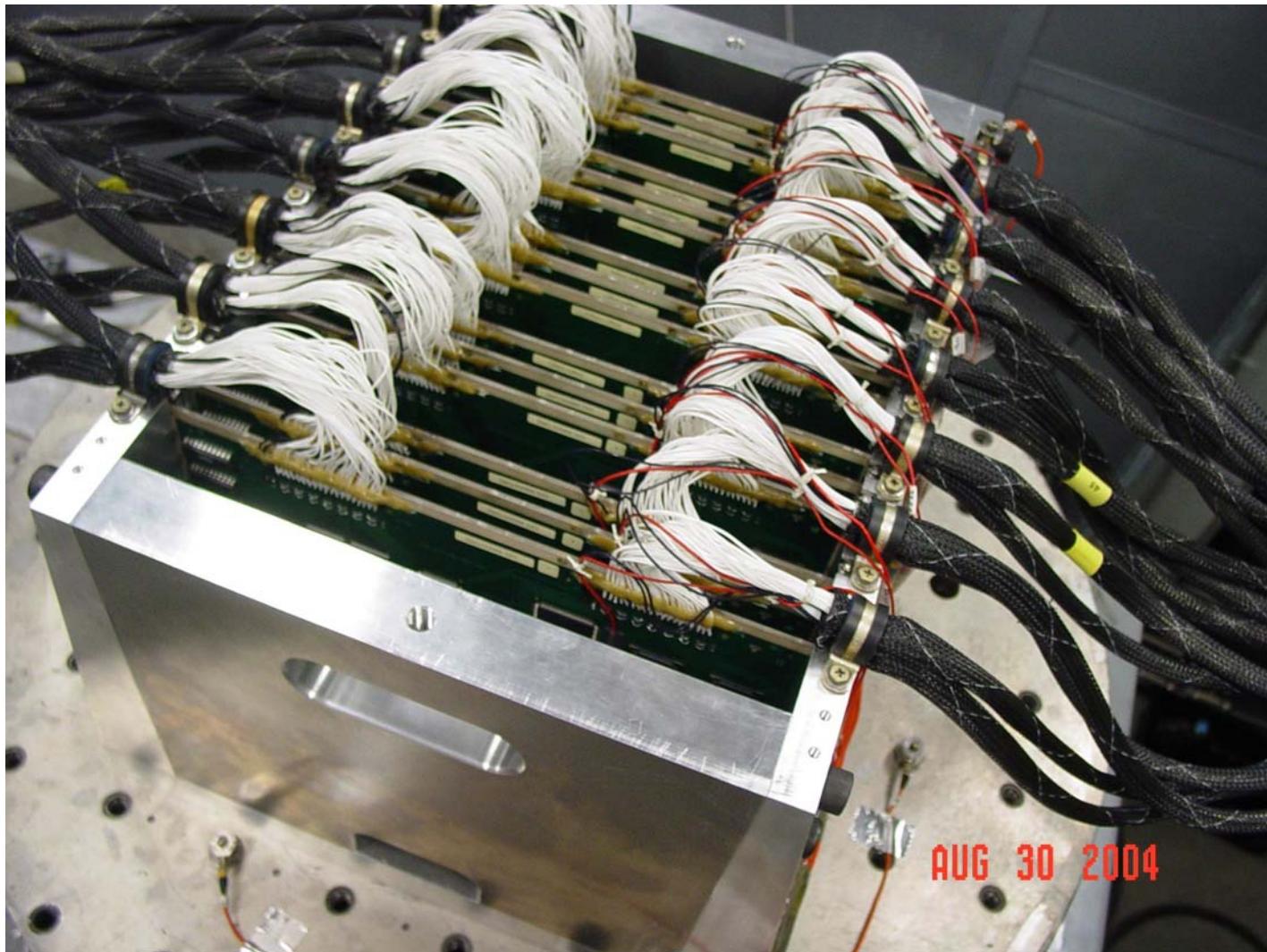


Figure 21. PWA's in Fixture ("Manufactured" PWA's)



Figure 22. PWA's in Fixture (Y-axis)

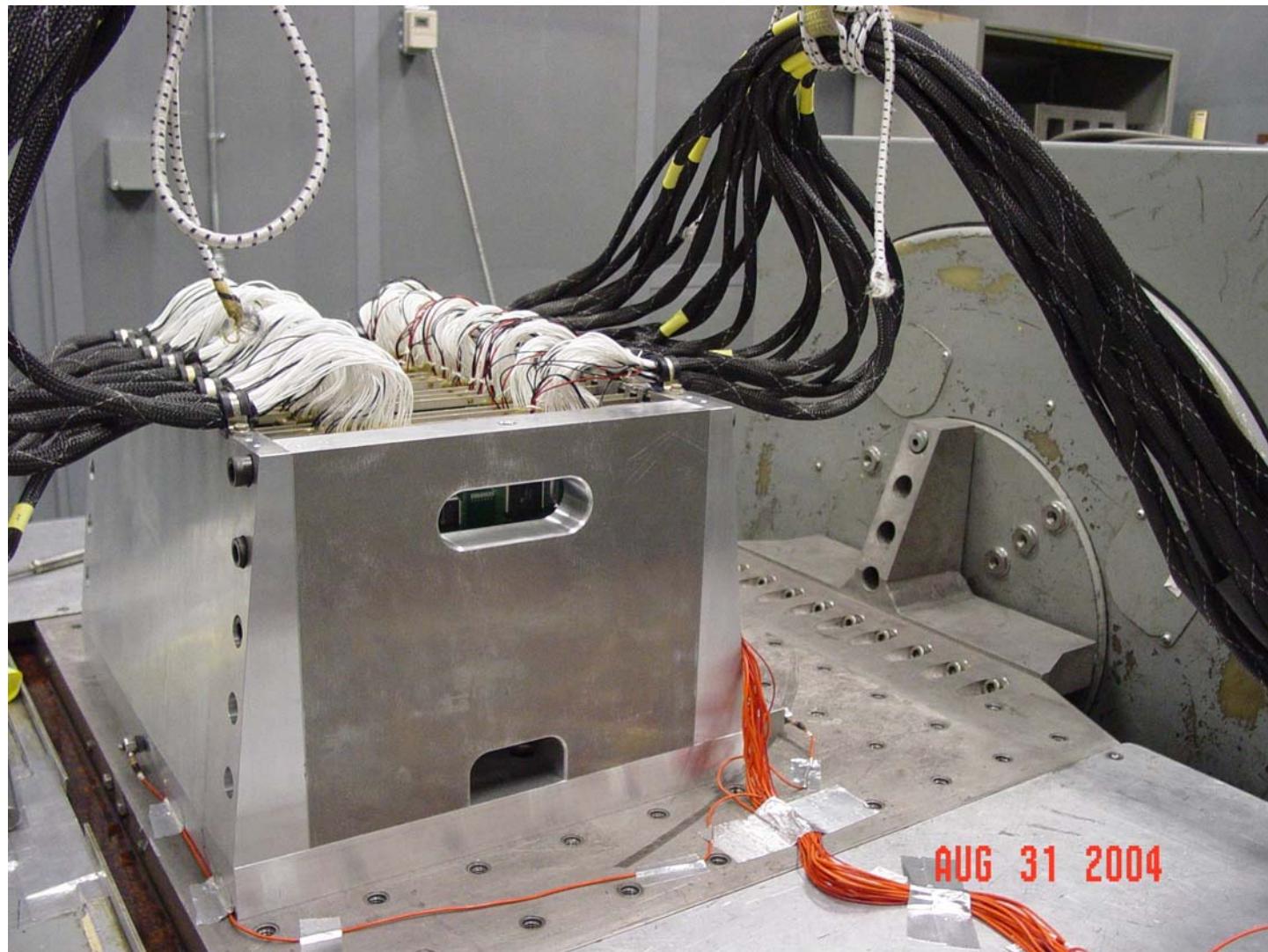


Figure 23. PWA's in Fixture (X-axis)

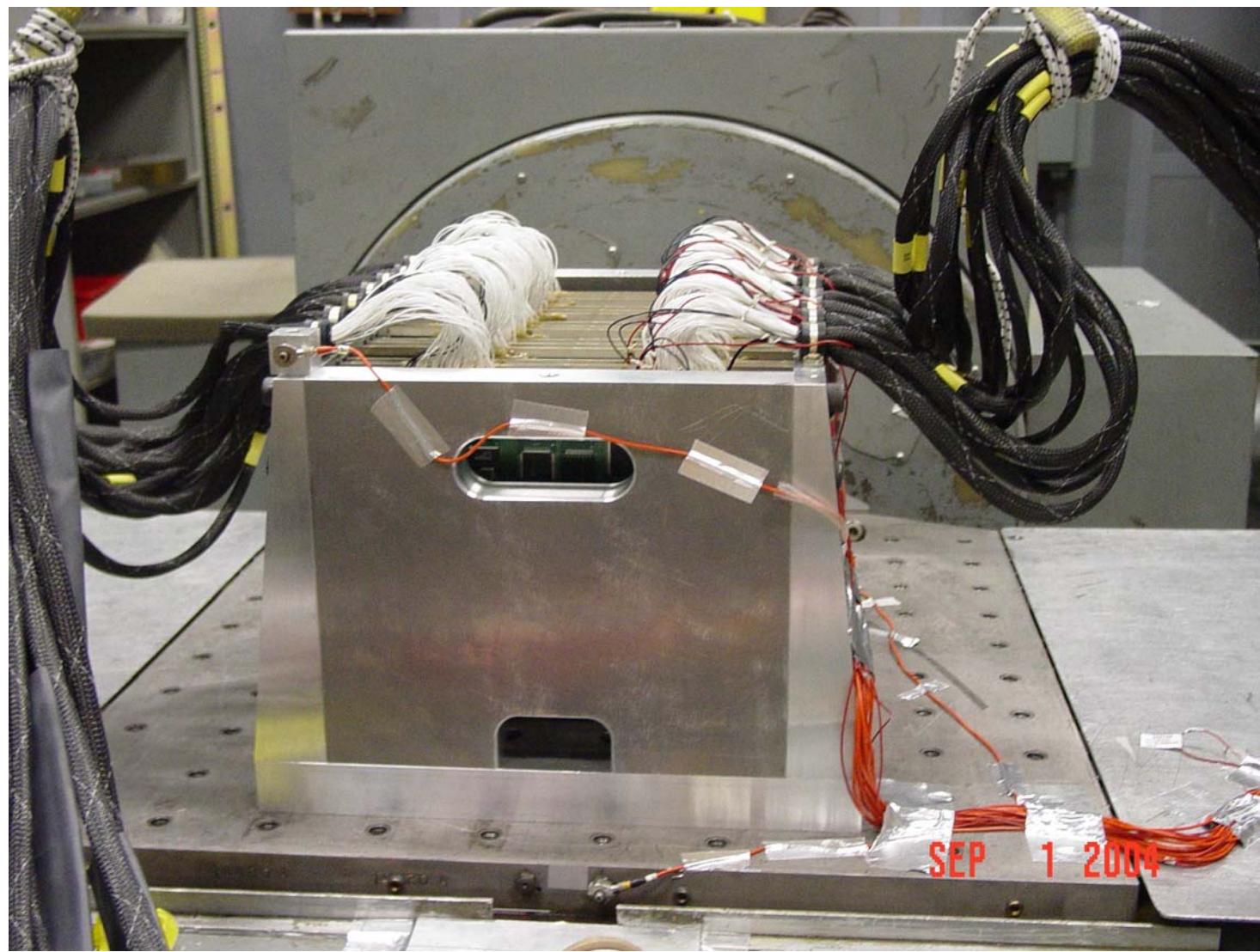


Figure 24. PWA's in Fixture (Z-axis)

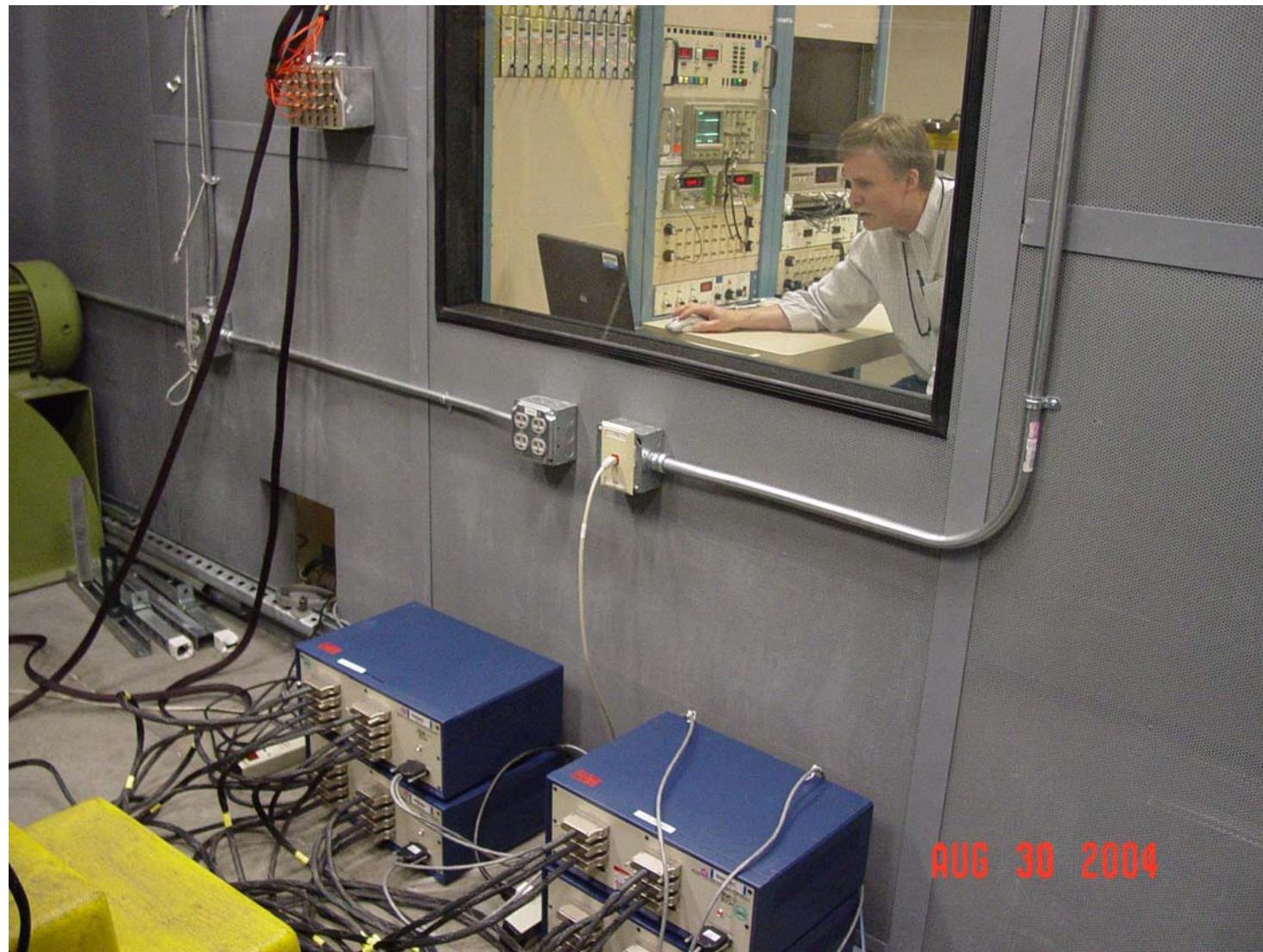


Figure 25. Event Detectors

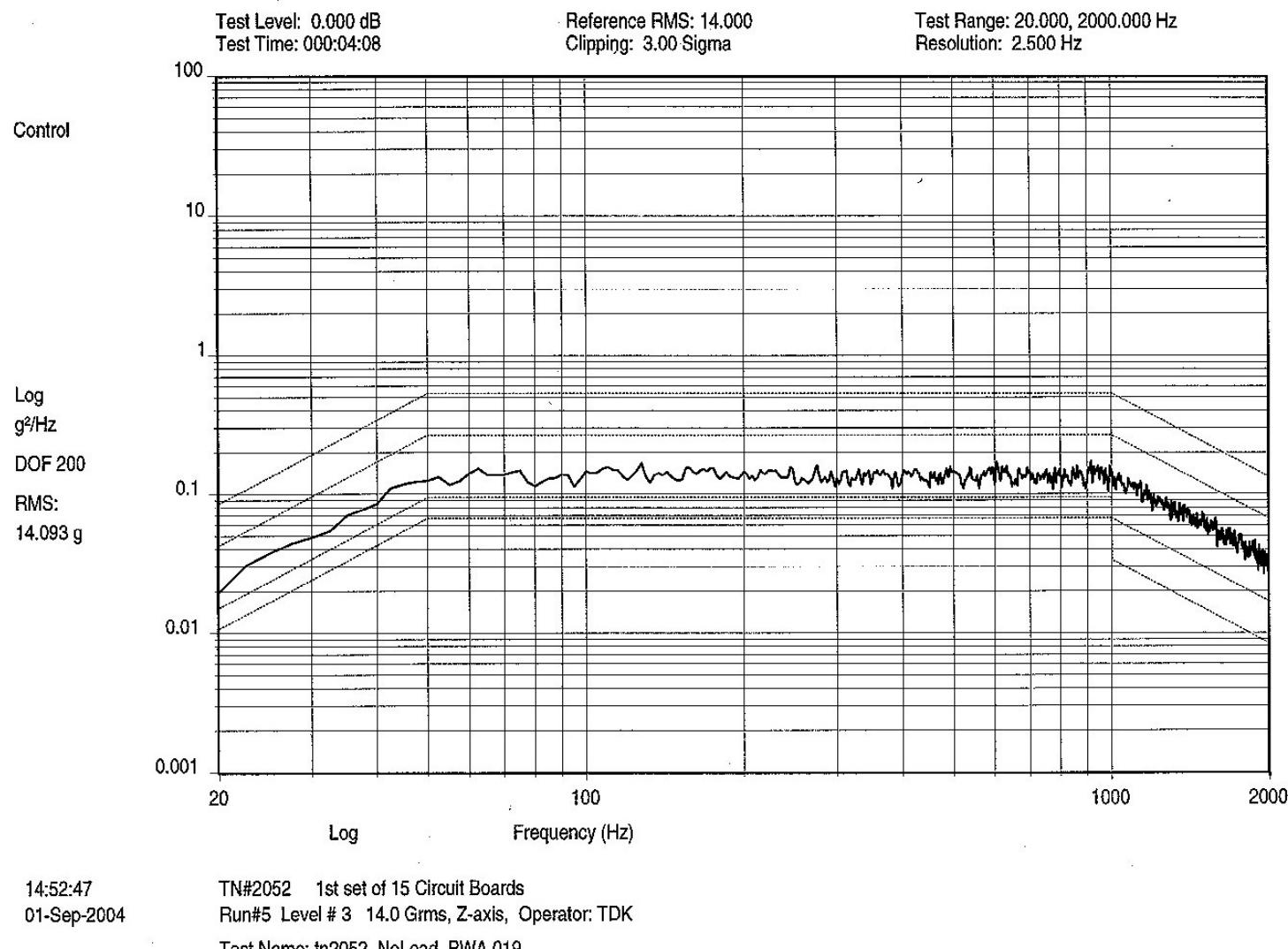


Figure 26. Input (14.0 Grms, Z-axis)

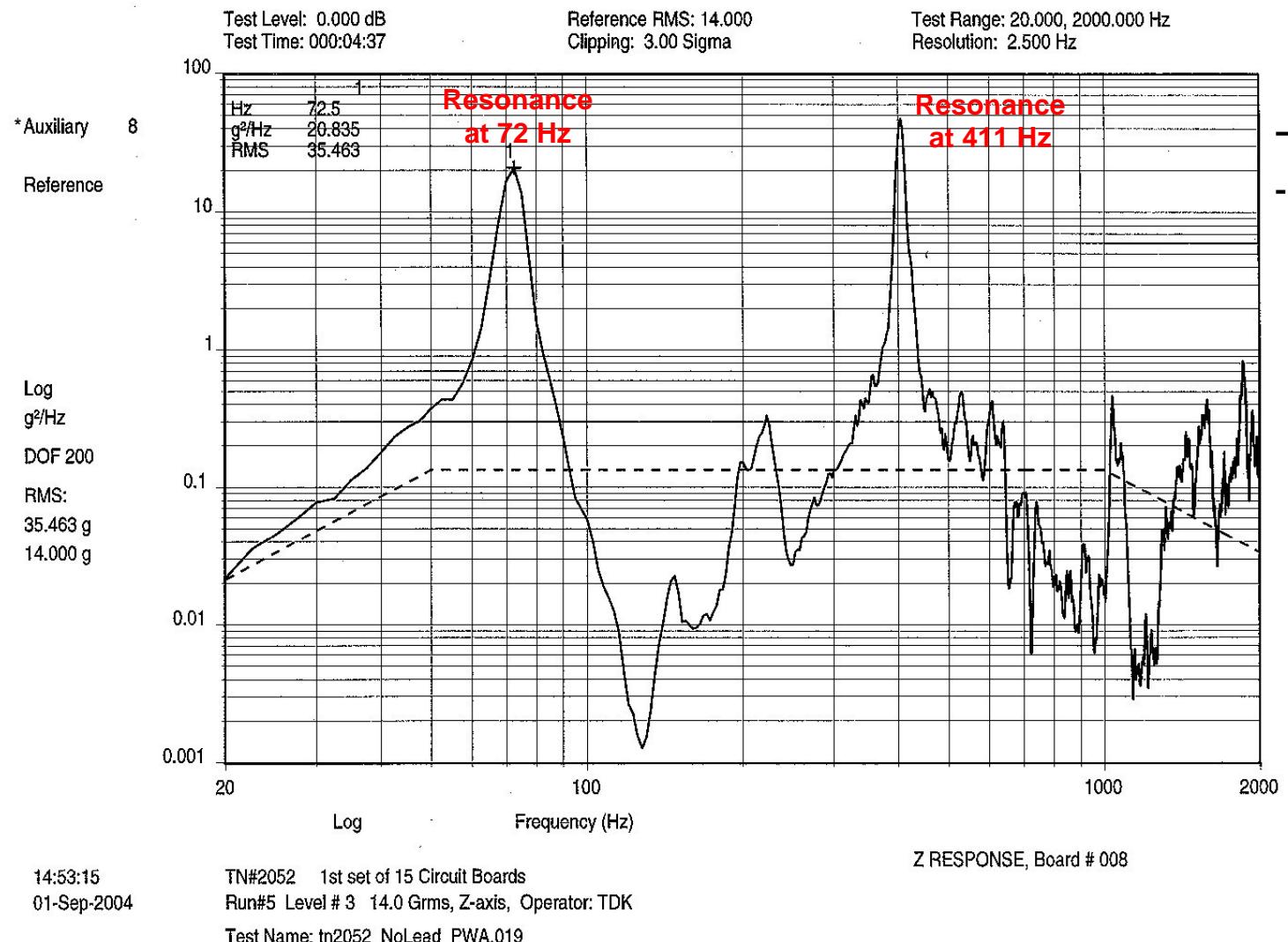
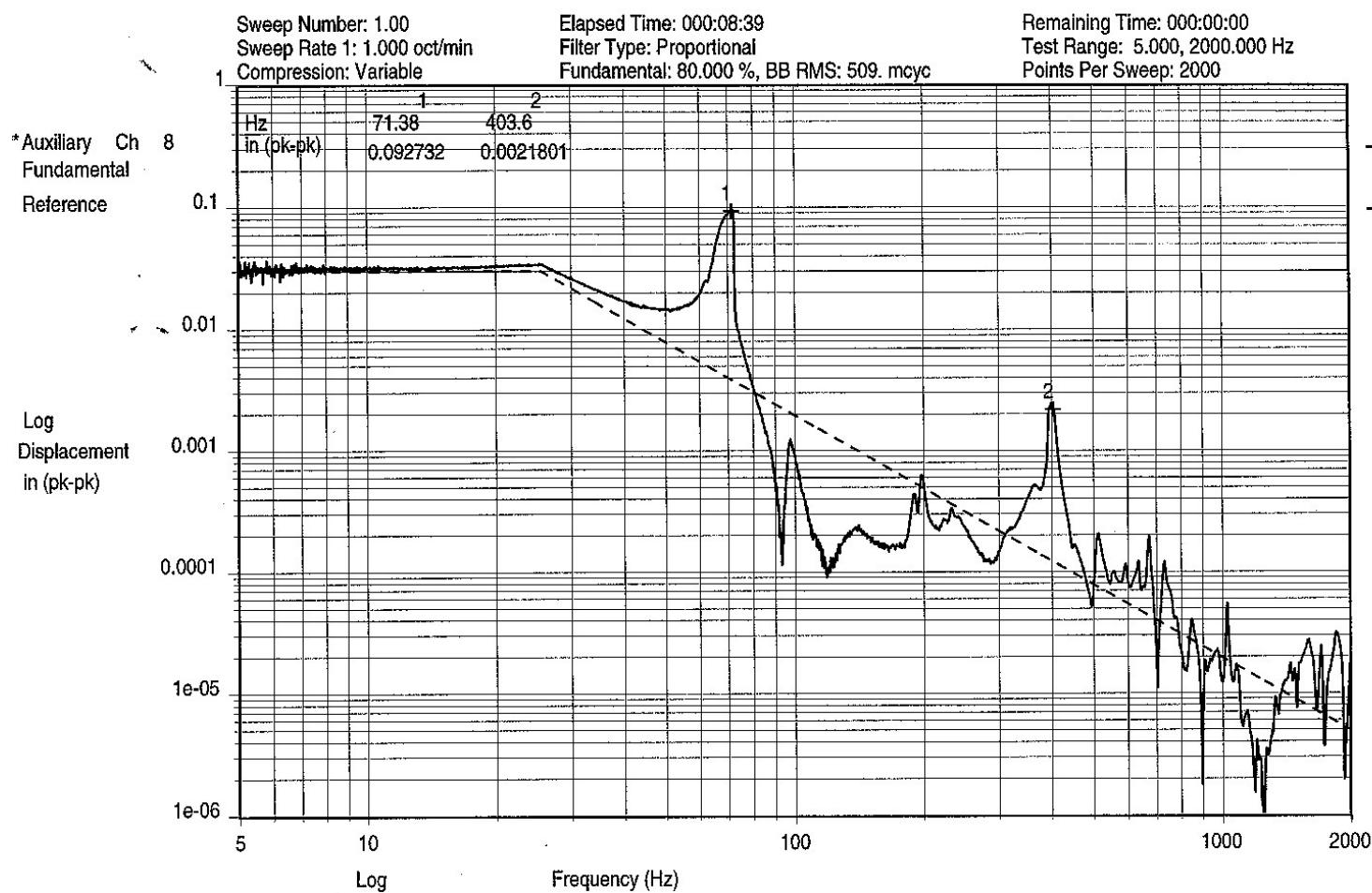


Figure 27. PWA Response (14.0 Grms, Z-axis, “Manufactured” PWA)



08:45:52
 02-Sep-2004

TN: 2052 No lead Circuit Board, 1st Set of 15 Boards
 RUN#6 Z-Axis, SINE SWEEP 1.0 Gpk Operator:TDK
 Sine Test Name: tn2052_NoLead_Circuit_bd.002

Z RESPONSE, Board # 008

Figure 28. Displacement vs. Frequency (“Manufactured” PWA)

Table 7. % of Components Failed ("Manufactured" PWA's, 836 Components in Test)

Axis	Test Level	% of Components Failed ("Manufactured" Boards)
Y-axis	9.9 Grms	0
X-axis	9.9 Grms	0
Z-axis	9.9 Grms	7.7
Z-axis	12.0 Grms	17.7
Z-axis	14.0 Grms	29.2
Z-axis	16.0 Grms	39.1
Z-axis	18.0 Grms	46.9
Z-axis	20.0 Grms	55.6
Z-axis	28.0 Grms	68.4

Table 8. % of Components Failed ("Rework" PWA's, 826 Components in Test)

Axis	Test Level	% of Components Failed ("Rework" Boards)
Y-axis	9.9 Grms	0
X-axis	9.9 Grms	0
Z-axis	9.9 Grms	11.7
Z-axis	12.0 Grms	27.5
Z-axis	14.0 Grms	39.4
Z-axis	16.0 Grms	46.1
Z-axis	18.0 Grms	54.8
Z-axis	20.0 Grms	61.7
Z-axis	28.0 Grms	75.3

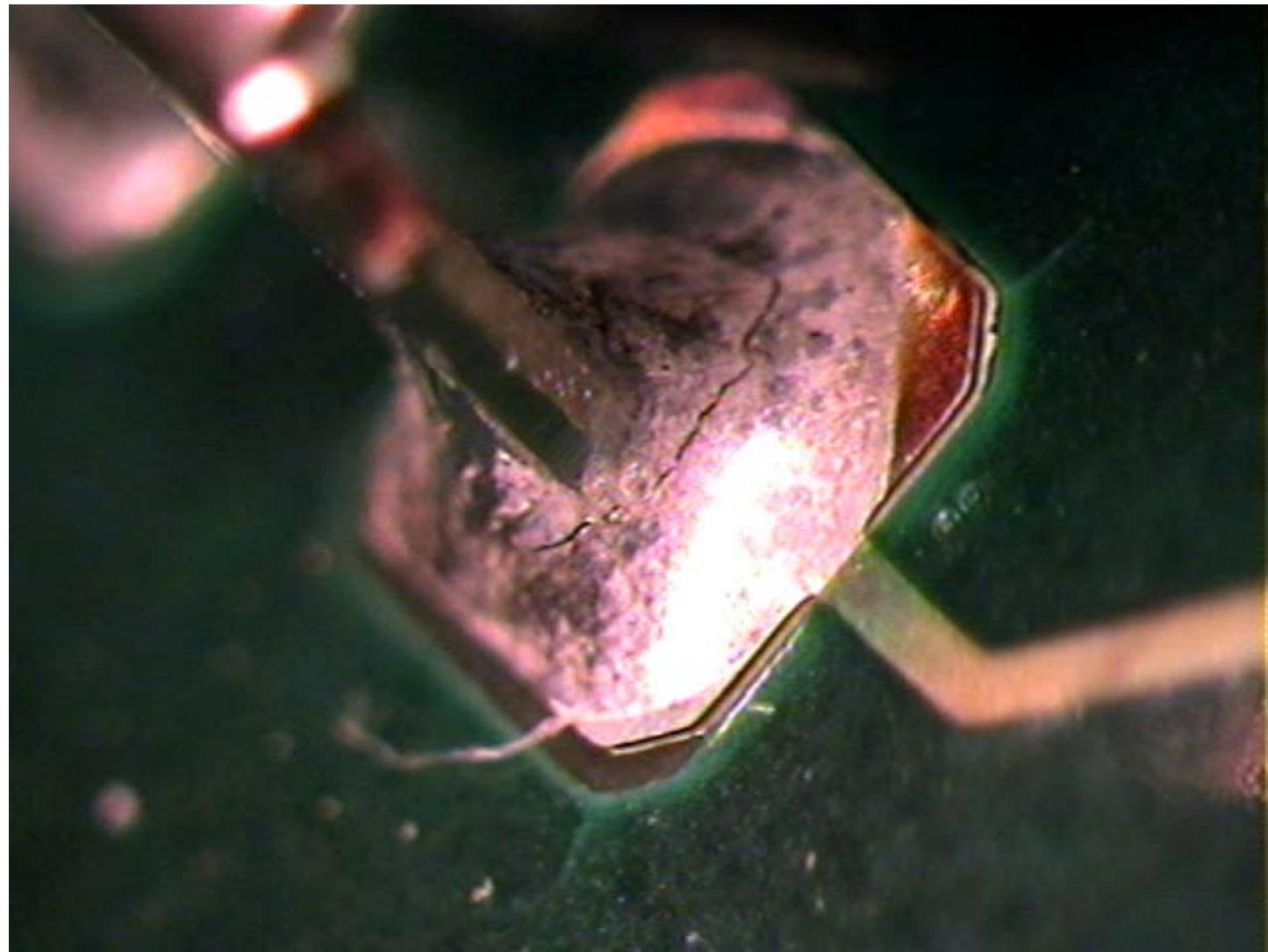


Figure 29. Test Vehicle ID 5 PDIP U8 100x

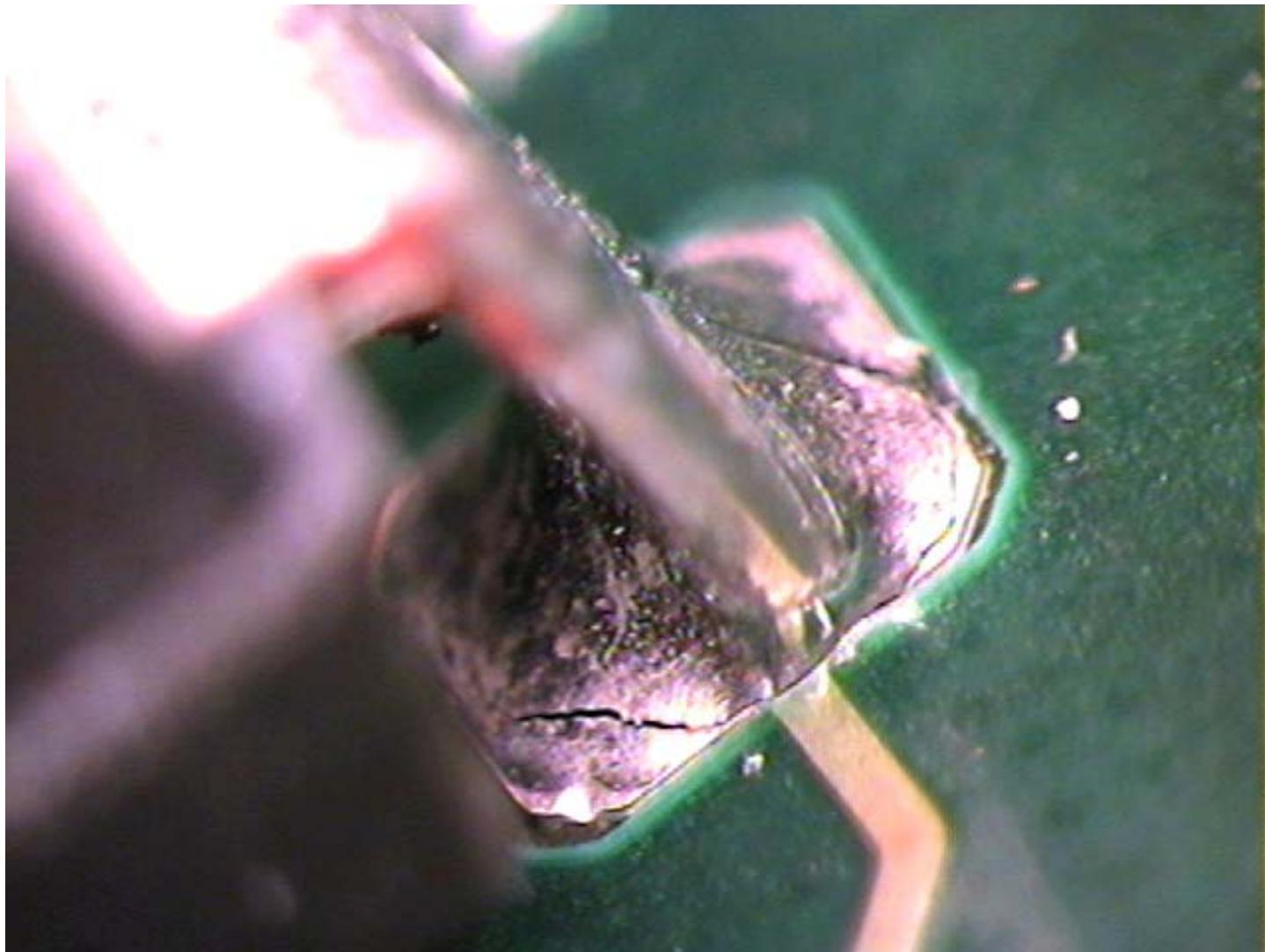


Figure 30. Test Vehicle ID 5 PDIP U63 100x

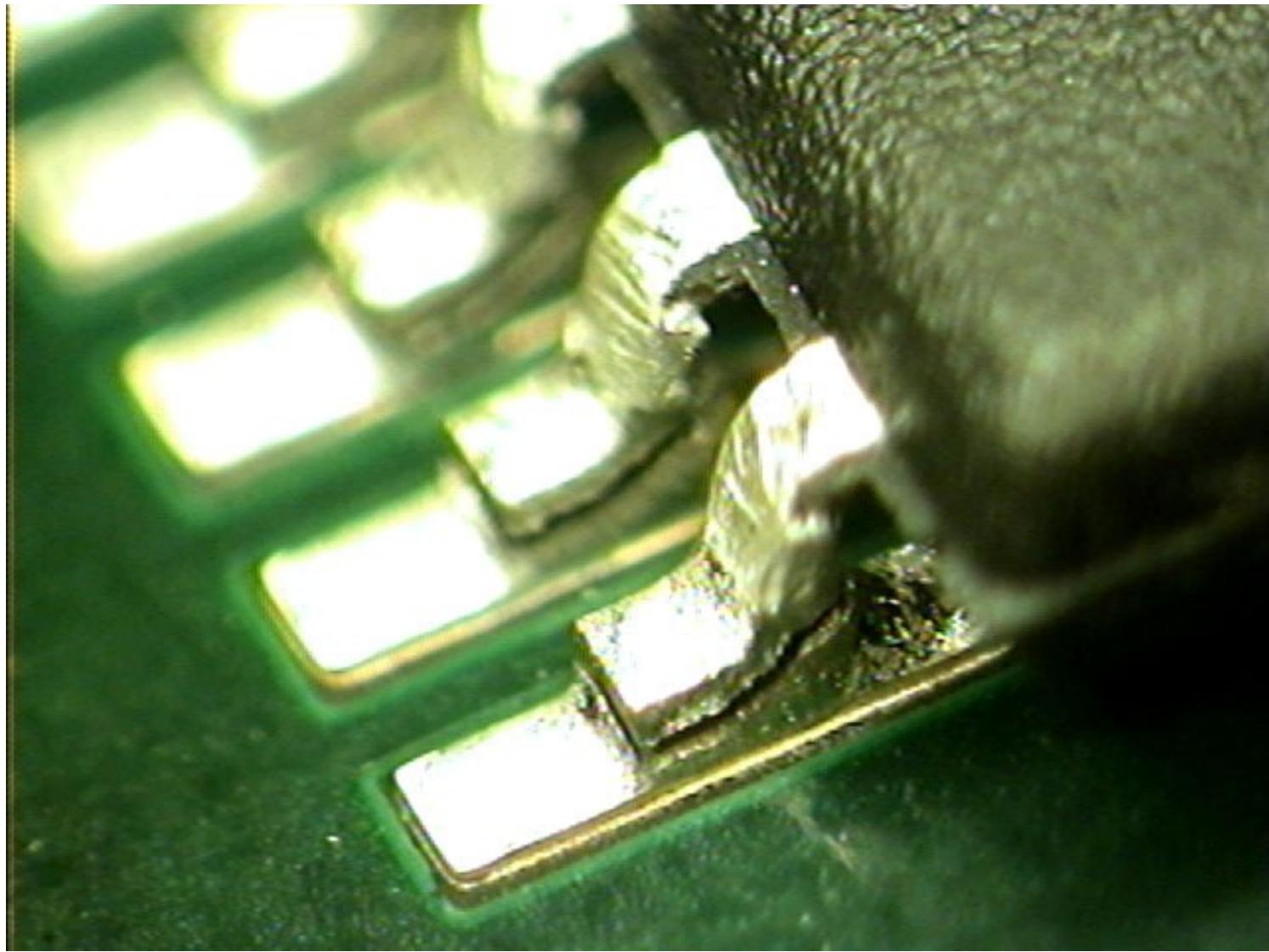


Figure 31. Test Vehicle ID 76 TSOP U26 100x

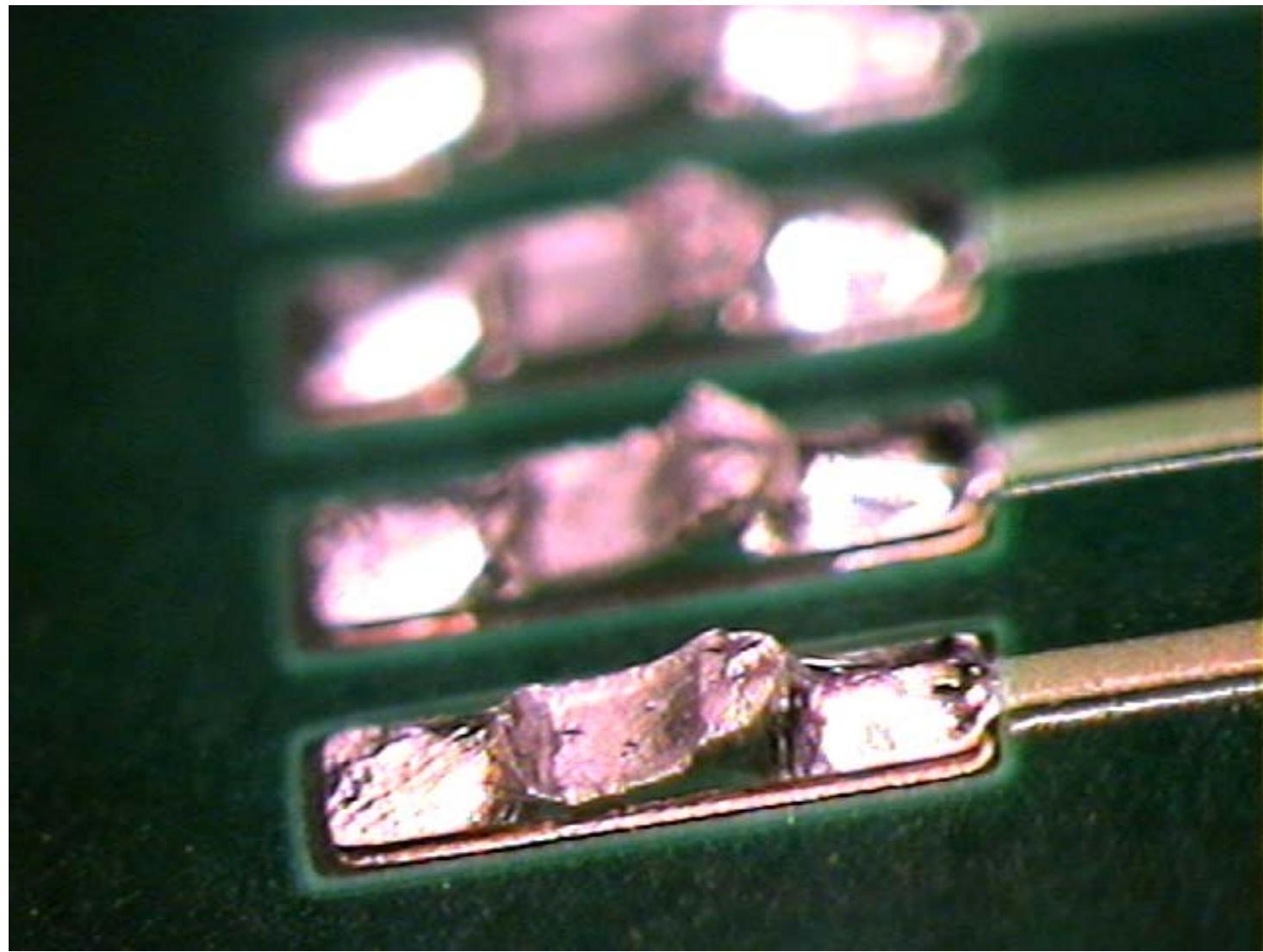


Figure 32. Test Vehicle ID 5 TSOP U29 100x

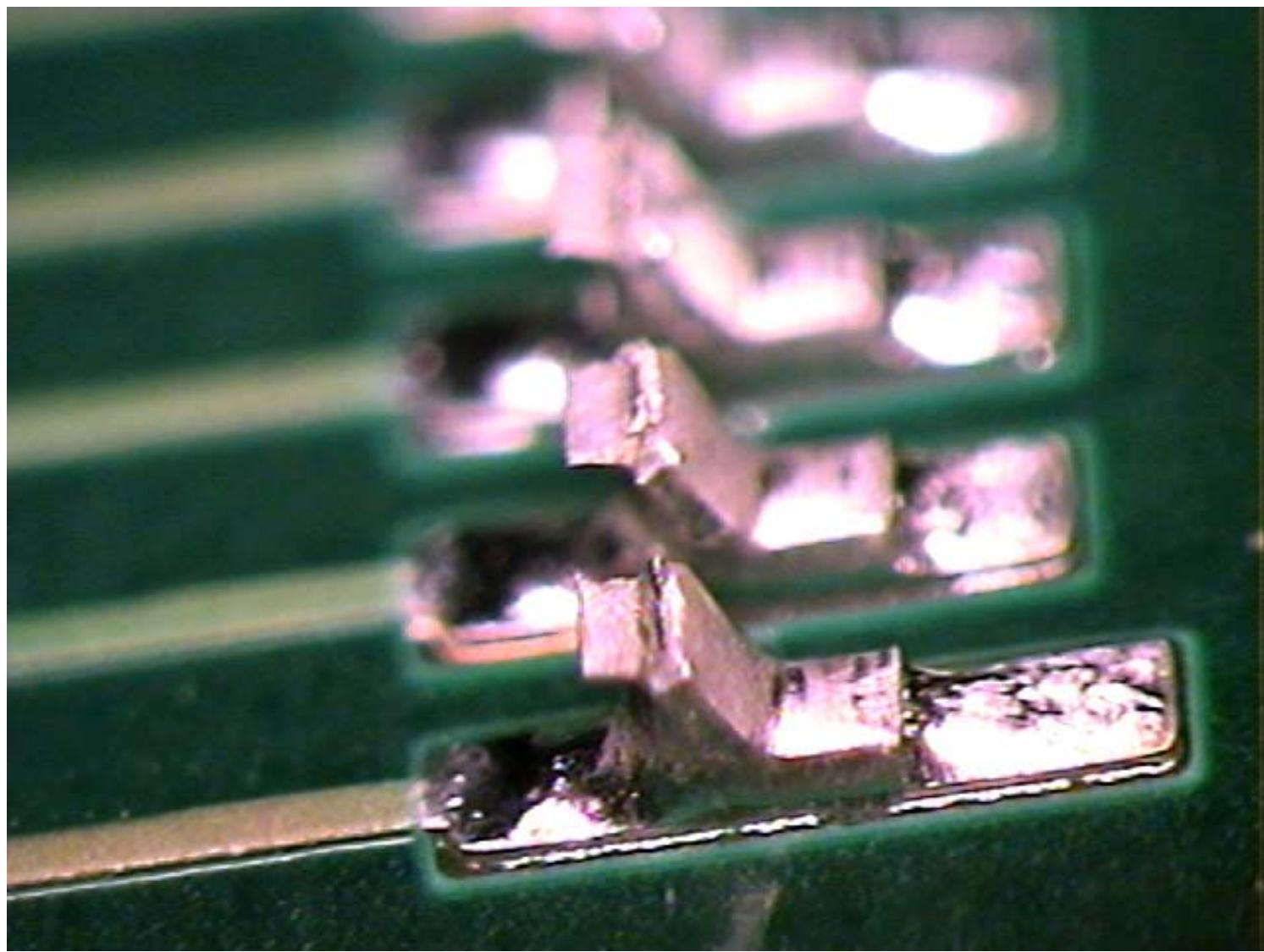


Figure 33. Test Vehicle ID 5 TSOP U29 100x

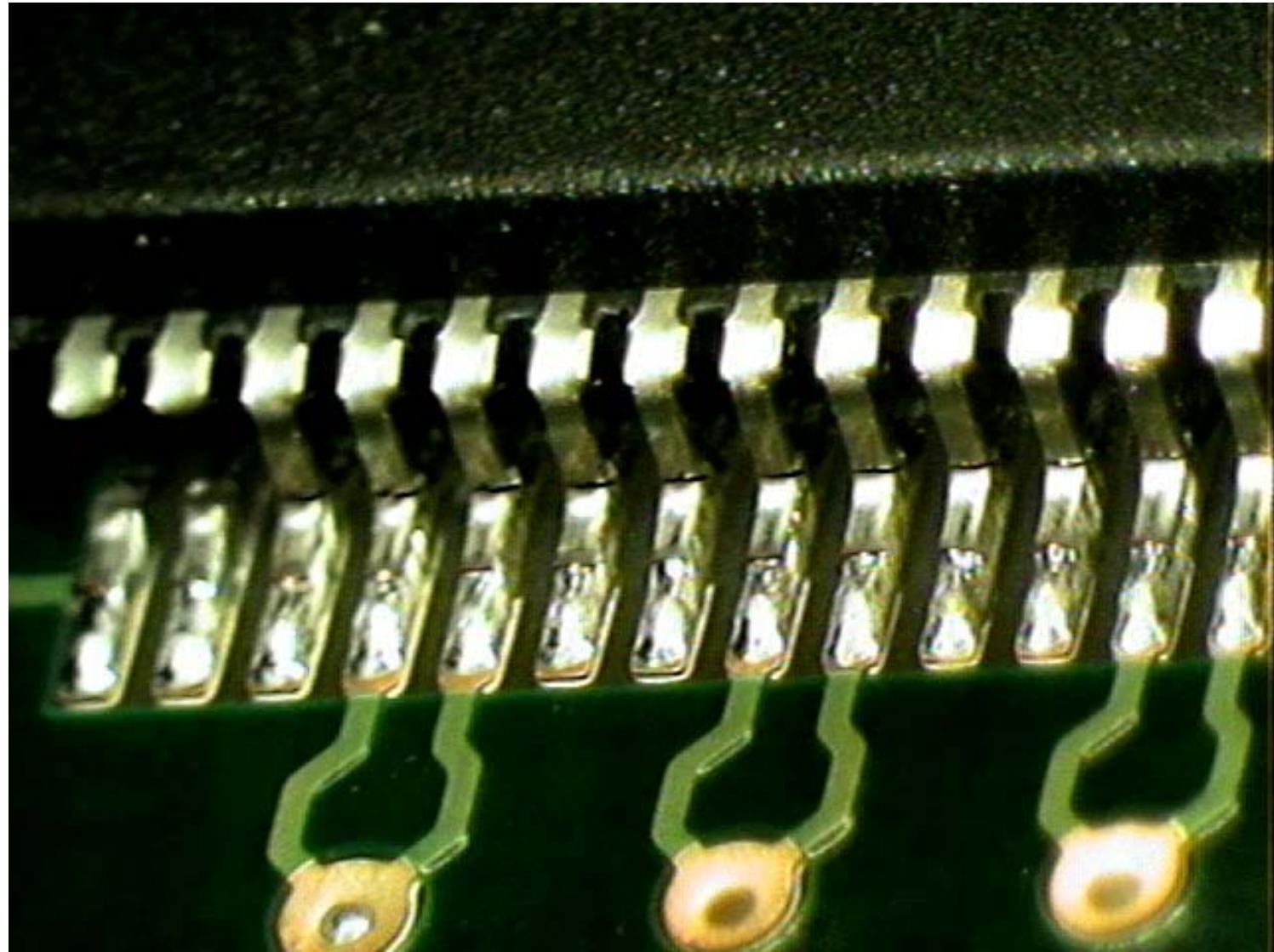


Figure 34. Test Vehicle ID 6 TQFP-208 U3 100x (Broken Leads, Missing Leads)

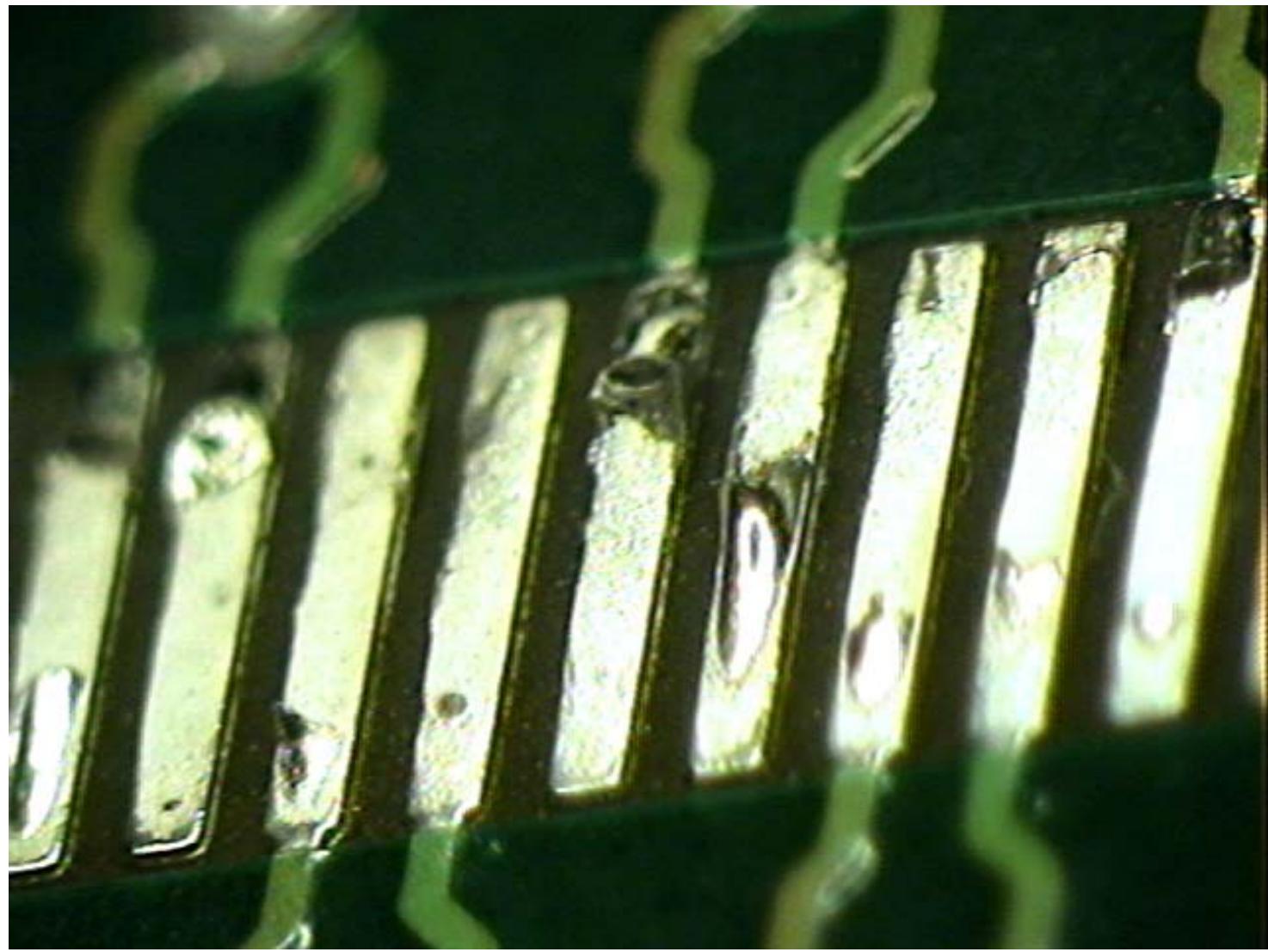


Figure 35. Test Vehicle ID 155 TQFP-208 U3 75x (Failures at Reworked Pad Interface)

Table 9. Components That Fell Off During Vibration Testing

Components That Fell Off During Vibration Testing					
	TSOP U12	TSOP U26	TSOP U16	TSOP U29	TQFP-208 U3
"Manufactured" Test Vehicle ID					
118		✓	✓		
117			✓	✓	
116					
115	✓	✓	✓		
114		✓	✓		
79	✓				
78					
77	✓		✓		
76					
75					
9				✓	
8	✓			✓	
7			✓	✓	
6					
5			✓		
"Rework" Test Vehicle ID					
185	✓		✓		
184	✓	✓	✓	✓	✓
183					✓
182					✓
180			✓	✓	✓
157	✓	✓		✓	✓
156	✓	✓	✓	✓	
155	✓	✓	✓	✓	✓
154					✓
153	✓		✓	✓	✓
50			✓		
49					
43			✓		✓
47			✓	✓	✓
46		✓			✓

Table 10. Ranking of Solders (“Manufactured” Test Vehicles)

			Relative Solder Ranking			
Component	Reference Designator	Solder/Finish	Sn37Pb	Sn3.9Ag0.6Cu	Sn3.4Ag1.0Cu3.3Bi	Sn0.7Cu0.05Ni
BGA-225	U4	Pb-Free/SAC or SnPb/SnPb	1	3	2	
BGA-225	U6	Pb-Free/SAC or SnPb/SnPb	1	3	2	
BGA-225	U18	Pb-Free/SAC or SnPb/SnPb	1	2	1	
BGA-225	U43	Pb-Free/SAC or SnPb/SnPb	1	3	2	
BGA-225	U55	Pb-Free/SAC or SnPb/SnPb	1	3	2	
BGA-225	U2	Pb-Free/SnPb or SnPb/SnPb	2	1	3	
BGA-225	U5	Pb-Free/SnPb or SnPb/SnPb	1	2	1	
BGA-225	U21	Pb-Free/SnPb or SnPb/SnPb	1	3	2	
BGA-225	U44	Pb-Free/SnPb or SnPb/SnPb	1	3	2	
BGA-225	U56	Pb-Free/SnPb or SnPb/SnPb	1	3	2	
CLCC-20	U10	SAC/SAC or SACB/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U14	SAC/SAC or SACB/SACB or SnPb/SnPb	2	3	1	
CLCC-20	U17	SAC/SAC or SACB/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U45	SAC/SAC or SACB/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U52	SAC/SAC or SACB/SACB or SnPb/SnPb	2	3	1	
CLCC-20	U9	Pb-Free/SnPb or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U13	Pb-Free/SnPb or SnPb/SnPb	2	3	1	
CLCC-20	U22	Pb-Free/SnPb or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U46	Pb-Free/SnPb or SnPb/SnPb	3	2	1	
CLCC-20	U53	Pb-Free/SnPb or SnPb/SnPb	1	3	2	
PDIP-20	U8	Pb-Free/NiPdAu or SnPb/NiPdAu	3	2		1
PDIP-20	U23	Pb-Free/NiPdAu or SnPb/NiPdAu	Not enough failures to rank			
PDIP-20	U35	Pb-Free/NiPdAu or SnPb/NiPdAu	3	2		1
PDIP-20	U49	Pb-Free/NiPdAu or SnPb/NiPdAu	3	2		1
PDIP-20	U59	Pb-Free/NiPdAu or SnPb/NiPdAu	Not enough failures to rank			

Table 11. Ranking of Solders (“Manufactured” Test Vehicles)

		Relative Solder Ranking				
Component	Reference Designator	Solder/Finish	Sn37Pb	Sn3.9Ag0.6Cu	Sn3.4Ag1.0Cu3.3Bi	Sn0.7Cu0.05Ni
PDIP-20	U11	Pb-Free/Sn or SnPb/Sn	2	3		1
PDIP-20	U30	Pb-Free/Sn or SnPb/Sn	1	2		1
PDIP-20	U38	Pb-Free/Sn or SnPb/Sn	2	1		1
PDIP-20	U51	Pb-Free/Sn or SnPb/Sn	2	3		1
PDIP-20	U63	Pb-Free/Sn or SnPb/Sn	2	3		1
TSOP-50	U12	Pb-Free/SnCu or SnPb/SnPb	1	2	3	
TSOP-50	U25	Pb-Free/SnCu or SnPb/SnPb	3	1	2	
TSOP-50	U29	Pb-Free/SnCu or SnPb/SnPb	2	1	1	
TSOP-50	U39	Pb-Free/SnCu or SnPb/SnPb	Not enough failures to rank			
TSOP-50	U61	Pb-Free/SnCu or SnPb/SnPb	Not enough failures to rank			
TSOP-50	U16	Pb-Free/SnPb or SnPb/SnPb	2	1	3	
TSOP-50	U24	Pb-Free/SnPb or SnPb/SnPb	3	2	1	
TSOP-50	U26	Pb-Free/SnPb or SnPb/SnPb	1	2	3	
TSOP-50	U40	Pb-Free/SnPb or SnPb/SnPb	Not enough failures to rank			
TSOP-50	U62	Pb-Free/SnPb or SnPb/SnPb	Not enough failures to rank			
PLCC-20	U15	Pb-Free/Sn or SnPb/Sn	1	3	2	
PLCC-20	U27	Pb-Free/Sn or SnPb/Sn	Not enough failures to rank			
PLCC-20	U28	Pb-Free/Sn or SnPb/Sn	Not enough failures to rank			
PLCC-20	U47	Pb-Free/Sn or SnPb/Sn	Not enough failures to rank			
PLCC-20	U54	Pb-Free/Sn or SnPb/Sn	Not enough failures to rank			
TQFP-144	U1	Pb-Free/Sn or SnPb/Sn	Broken leads			
TQFP-144	U7	Pb-Free/Sn or SnPb/Sn	Not enough failures to rank			
TQFP-144	U20	Pb-Free/Sn or SnPb/Sn	Broken leads			
TQFP-144	U41	Pb-Free/Sn or SnPb/Sn	Broken leads			
TQFP-144	U58	Pb-Free/Sn or SnPb/Sn	Broken leads			
TQFP-208	U3	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			
TQFP-208	U31	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			
TQFP-208	U34	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			
TQFP-208	U48	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			
TQFP-208	U57	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			

Table 12. Ranking of Solders (“Rework” Test Vehicles)

			Relative Solder Ranking (All Solder Joints are Contaminated with Pb)			
Component	Reference Designator	Solder/Finish	Sn37Pb	Sn3.9Ag0.6Cu	Sn3.4Ag1.0Cu3.3Bi	Sn0.7Cu0.05Ni (DIP's Only)
BGA-225 (Reworked)	U4	flux only/SAC or flux only/SnPb	1	2	na	
BGA-225 (Reworked)	U18	flux only/SAC or flux only/SnPb	1	1	na	
BGA-225	U2	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U5	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U6	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U21	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U43	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U44	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U55	SnPb/SAC or SnPb/SnPb	1	2	na	
BGA-225	U56	SnPb/SAC or SnPb/SnPb	1	2	na	
CLCC-20	U9	SnPb/SAC or SnPb/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U10	SnPb/SAC or SnPb/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U13	SnPb/SAC or SnPb/SACB or SnPb/SnPb	1	3	2	
CLCC-20	U14	SnPb/SAC or SnPb/SACB or SnPb/SnPb	1	1	2	
CLCC-20	U17	SnPb/SAC or SnPb/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U22	SnPb/SAC or SnPb/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U45	SnPb/SAC or SnPb/SACB or SnPb/SnPb	Not enough failures to rank			
CLCC-20	U46	SnPb/SAC or SnPb/SACB or SnPb/SnPb	3	2	1	
CLCC-20	U52	SnPb/SAC or SnPb/SACB or SnPb/SnPb	1	2	3	
CLCC-20	U53	SnPb/SAC or SnPb/SACB or SnPb/SnPb	1	3	2	
PDIP-20 (Reworked)	U23	Pb-Free/NiPdAu or SnPb/NiPdAu	1	2		1
PDIP-20 (Reworked)	U59	Pb-Free/NiPdAu or SnPb/NiPdAu	1	3		2
TSOP-50 (Reworked)	U12	Pb-Free/SnCu or SnPb/SnPb	1	2	3	
TSOP-50 (Reworked)	U25	Pb-Free/SnCu or SnPb/SnPb	3	1	2	
TQFP-208 (Reworked)	U3	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			
TQFP-208 (Reworked)	U57	Pb-Free/NiPdAu or SnPb/NiPdAu	Broken leads			

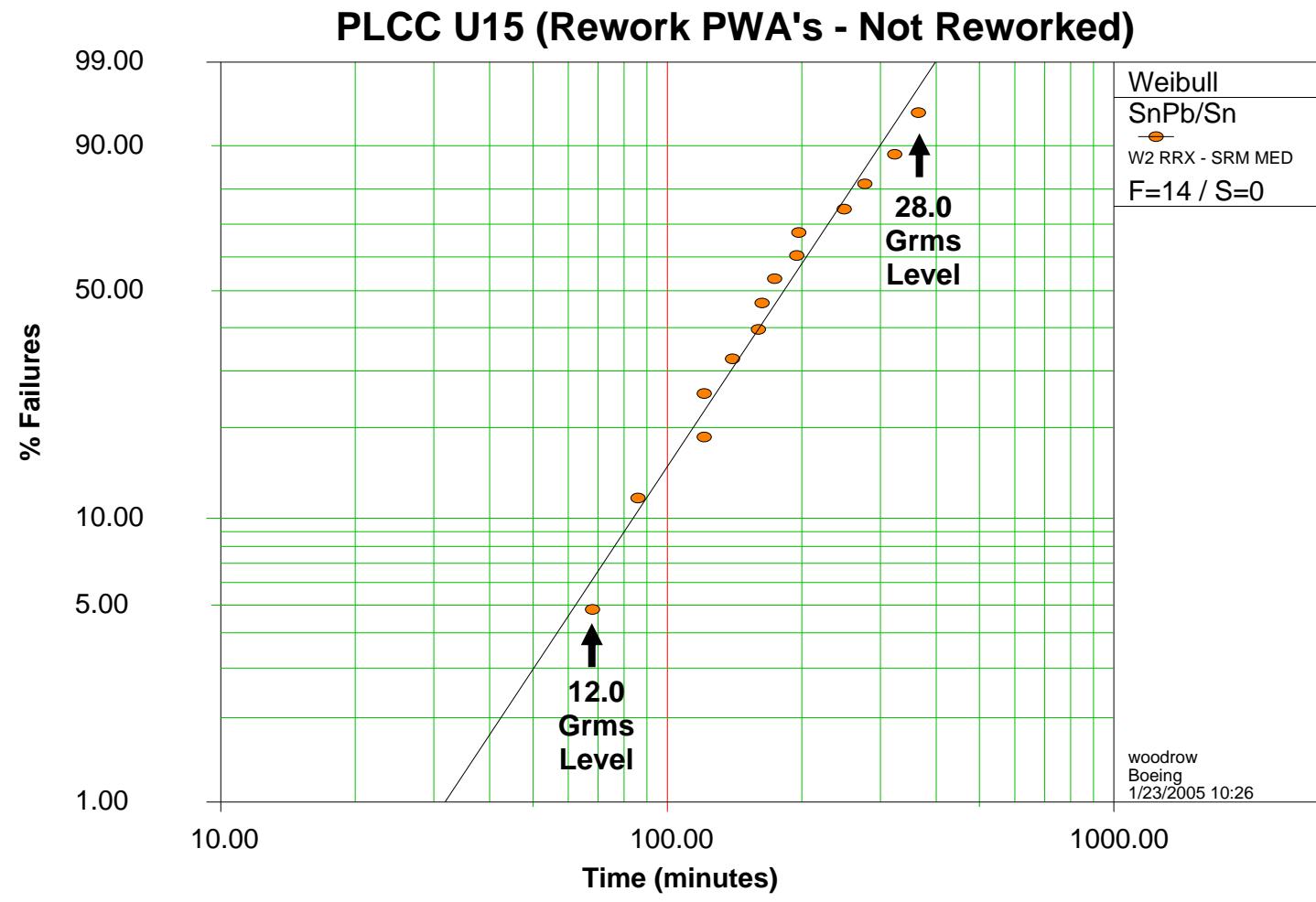


Figure 36. Example of How Data Can Be Fit Using Weibull Analysis

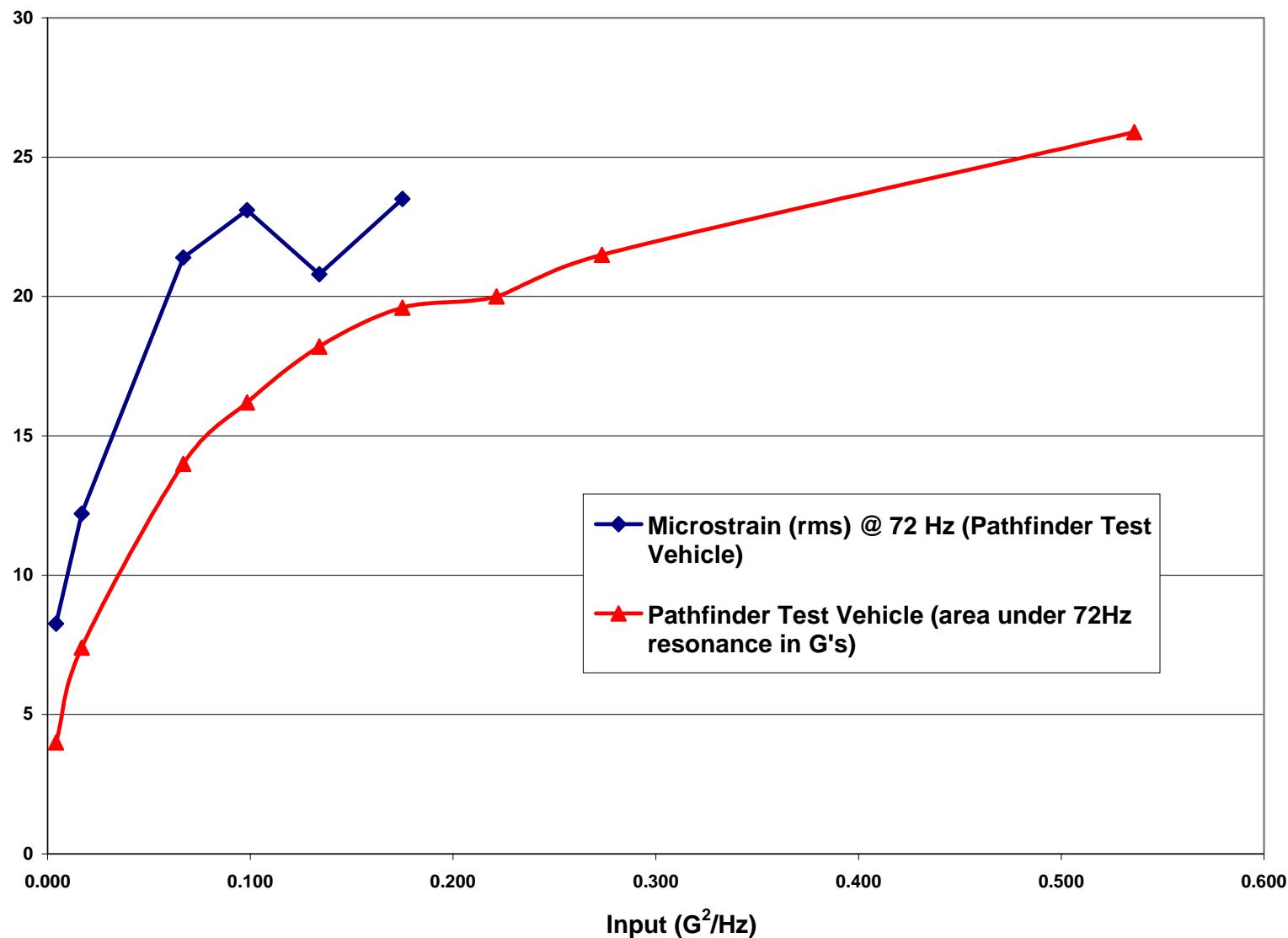


Figure 37. Comparison of Strain Gage Data and Test Vehicle Response

**Appendix A. Post-Test Inspection for Broken Leads
("“Manufactured”” PWA’s)**

BOARD	ID# 5	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	7 missing leads in corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked lead in corner
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	cracked solder joints (side away from board edge)
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	no broken leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	no broken leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	no broken leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	no broken leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	cracked lead near corner
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 6	
Ref Des	Component	Comments
U1	TQFP-144	leads beginning to crack
U2	BGA-225	
U3	TQFP-208	missing 3 leads on corner of part, multiple broken leads along same side
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	cracked leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	cracked solder joints (side away from board edge)
U30	PDIP-20	no broken leads
U31	TQFP-208	broken lead (missing tip)
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	leads beginning to crack
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing lead in corner
U58	TQFP-144	cracked leads
U59	PDIP-20	
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 7	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	broken lead (tip missing)
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	no broken leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corner
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID # 8	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing 5 leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	no broken leads
U31	TQFP-208	no broken leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	no broken leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	2 missing leads in corner
U58	TQFP-144	cracked leads
U59	PDIP-20	
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID # 9	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corner
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing 1 lead on corner
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 75	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	9 missing leads in corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	cracked solder joint (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joint (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	part missing 1 lead on corner
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	part missing 11 leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 76	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing 11 leads on corner
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	missing lead in corner
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing 9 leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 77	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	missing 14 leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	cracked leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	part missing, leads broken off on one side, leads broken or pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads broken or pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	cracked solder joints (on side away from board edge)
U30	PDIP-20	no broken leads
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing 18 leads on corners
U58	TQFP-144	missing lead in corner
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 78	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	missing 22+C57 leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing 17 leads on corners
U58	TQFP-144	missing lead in corner
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 79	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	missing 9 leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	part missing, leads broke off or pulled out of solder on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	2 missing leads in corner
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing 11 leads on corners
U58	TQFP-144	missing leads on corners
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 114	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	leads pulled out of solder (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	no broken leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	no broken leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	missing lead
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	missing lead in corner
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	no broken leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corner near board edge, corner away from board edge)

BOARD	ID# 115	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	missing lead in corner
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

BOARD	ID# 116	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	leads pulled out of solder (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	no broken leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	missing lead in corner
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 117	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	leads pulled out of solder (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	leads pulled out of solder (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	no broken leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 118	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	no broken leads
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	leads pulled out of solder (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	missing lead in corner
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	no broken leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	missing leads in corners
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	no broken leads

Appendix B. Post-Test Inspection for Broken Leads ("Rework" PWAs)

BOARD		
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	leads beginning to crack
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	no broken leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	no broken leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	no broken leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing lead on corner
U58	TQFP-144	2 broken leads (missing tips)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 46	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads pulled out of solder on both sides of part
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	broken lead
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 47	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	broken lead (missing tip)
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	cracked solder joint (corner near board edge)
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	leads beginning to crack
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	leads beginning to crack
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing lead in corner
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge, corner away from board edge)

BOARD	ID# 49	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	no broken leads
U12	TSOP-50	cracked solder joints (on away from board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	leads beginning to crack
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing lead on corner
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 50	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	missing leads on corners
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	cracked lead
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	no broken leads
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	cracked solder joints (on side away from board edge)
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corner near board edge; corner away from board edge)

BOARD	ID# 153	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	leads pulled out of solder (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	leads beginning to crack
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads, tip of lead missing
U59	PDIP-20	cracked solder joint (corner near board edge)
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 154	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	broken leads in corner
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 155	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	cracked leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	part missing, leads pulled out of solder both sides
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads pulled out of solder on both sides
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	3 broken leads (missing tips)
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 156	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	broken lead near corner
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	part missing, leads broken off or pulled out of solder on both sides
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder on both sides
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	broken leads (missing tips)
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	broken lead (missing tip)
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joint (corner near board edge)

BOARD	ID# 157	
Ref Des	Component	Comments
U1	TQFP-144	cracked leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	cracked solder joint (corner near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joint (corner near board edge)
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder, leads pulled out of solder on opposite side
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joint (corner near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joint (corner near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joint (corner near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	broken lead (missing tip)
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joint (corner near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joint (corner near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corner near board edge, corner away from board edge)

BOARD	ID# 180	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or leads pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joints (corners near board edge)
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U30	PDIP-20	cracked solder joints (corners near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	leads beginning to crack
U35	PDIP-20	cracked solder joints (corners near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joints (corners near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	broken lead (missing tip)
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joints (corners near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joints (corners near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	cracked leads
U59	PDIP-20	cracked solder joint (corner near board edge)
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corners near board edge, corner away from board edge)

BOARD	ID# 182	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joints (corners near board edge)
U12	TSOP-50	cracked solder joints (on side near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	leads beginning to crack
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (on side near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joints (corners near board edge)
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joints (corners near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joints (corners near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	cracked leads
U48	TQFP-208	no broken leads
U49	PDIP-20	cracked solder joints (corners near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joints (corners near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corners near board edge, corner away from board edge)

BOARD	ID# 183	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	no broken leads
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joints (corners near board edge)
U12	TSOP-50	cracked solder joints (on side C57near board edge)
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	no broken leads
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	cracked solder joints (near board edge)
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	cracked solder joints (corners near board edge)
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	cracked leads
U35	PDIP-20	cracked solder joints (corners near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joints (corners near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	cracked leads
U49	PDIP-20	cracked solder joints (corners near board edge)
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corners near board edge, corner away from board edge)

BOARD	ID# 184	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken or and pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	cracked leads
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joints (corners near board edge)
U12	TSOP-50	part missing, leads pulled out of solder
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on other side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	2 broken leads (missing tips)
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	part missing, leads broken off or pulled out of solder
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on other side
U30	PDIP-20	cracked solder joints (corners near board edge)
U31	TQFP-208	cracked leads
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	12 broken leads
U35	PDIP-20	cracked solder joints (corners near board edge)
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	cracked solder joints (corners near board edge)
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	cracked leads
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	cracked solder joints (corners near board edge)
U50	Hybrid-30	
U51	PDIP-20	cracked solder joints (corners near board edge)
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	missing leads on corners
U58	TQFP-144	broken lead (missing tip)
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corners near board edge, corner away from board edge)

BOARD	ID# 185	
Ref Des	Component	Comments
U1	TQFP-144	no broken leads
U2	BGA-225	
U3	TQFP-208	part missing, leads broken off or pulled out of solder
U4	BGA-225	
U5	BGA-225	
U6	BGA-225	
U7	TQFP-144	leads beginning to crack
U8	PDIP-20	cracked solder joints (corners near board edge)
U9	CLCC-20	
U10	CLCC-20	
U11	PDIP-20	cracked solder joints (corners near board edge)
U12	TSOP-50	part missing, leads broken off or pulled out of solder on one side, leads pulled out of solder on opposite side
U13	CLCC-20	
U14	CLCC-20	
U15	PLCC-20	no broken leads
U16	TSOP-50	part missing, leads broken off on one side, leads pulled out of solder on opposite side
U17	CLCC-20	
U18	BGA-225	
U19	CSP-100	
U20	TQFP-144	cracked leads
U21	BGA-225	
U22	CLCC-20	
U23	PDIP-20	no broken leads
U24	TSOP-50	no broken leads
U25	TSOP-50	no broken leads
U26	TSOP-50	no broken leads
U27	PLCC-20	no broken leads
U28	PLCC-20	no broken leads
U29	TSOP-50	no broken leads
U30	PDIP-20	no broken leads
U31	TQFP-208	leads beginning to crack
U32	Hybrid-30	
U33	Hybrid-30	
U34	TQFP-208	leads beginning to crack
U35	PDIP-20	no broken leads
U36	CSP-100	
U37	CSP-100	
U38	PDIP-20	no broken leads
U39	TSOP-50	no broken leads
U40	TSOP-50	no broken leads
U41	TQFP-144	leads beginning to crack
U42	CSP-100	
U43	BGA-225	
U44	BGA-225	
U45	CLCC-20	
U46	CLCC-20	
U47	PLCC-20	no broken leads
U48	TQFP-208	leads beginning to crack
U49	PDIP-20	no broken leads
U50	Hybrid-30	
U51	PDIP-20	no broken leads
U52	CLCC-20	
U53	CLCC-20	
U54	PLCC-20	no broken leads
U55	BGA-225	
U56	BGA-225	
U57	TQFP-208	broken lead (missing tip)
U58	TQFP-144	cracked leads
U59	PDIP-20	no broken leads
U60	CSP-100	
U61	TSOP-50	no broken leads
U62	TSOP-50	no broken leads
U63	PDIP-20	cracked solder joints (corners near board edge, corner away from board edge)

Appendix C. Test Data (““Manufactured”” PWA’s)

Table C-1. BGA-225 U4 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms	
77	SAC/SAC	60	60	6							
79	SAC/SAC	60	60	9							
75	SAC/SAC	60	60	10							
76	SAC/SAC	60	60	16							
78	SAC/SAC	60	60	60	37						
116	SACB/SAC	60	60	5							
117	SACB/SAC	60	60	11							
114	SACB/SAC	60	60	23							
118	SACB/SAC	60	60	32							
115	SACB/SAC	60	60	37							
6	SnPb/SnPb	60	60	20							
5	SnPb/SnPb	60	60	49							
7	SnPb/SnPb	60	60	60	1						
8	SnPb/SnPb	60	60	60	22						
9	SnPb/SnPb	60	60	60	60	4					

Table C-2. BGA-225 U6 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SAC	60	60	17						
77	SAC/SAC	60	60	60	24					
76	SAC/SAC	60	60	60	43					
75	SAC/SAC	60	60	60	60	31				
78	SAC/SAC	60	60	60	60	53				
116	SACB/SAC	60	60	60	16					
114	SACB/SAC	60	60	60	58					
118	SACB/SAC	60	60	60	60	54				
115	SACB/SAC	60	60	60	60	60	19			
117	SACB/SAC	60	60	60	60	60	26			
6	SnPb/SnPb	60	60	60	57					
5	SnPb/SnPb	60	60	60	60	25				
8	SnPb/SnPb	60	60	60	60	60	12			
7	SnPb/SnPb	60	60	60	60	60	60	60	30	
9	SnPb/SnPb	60	60	60	60	60	60	60	60	5

Table C-3. BGA-225 U18 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SAC	60	60	60	60	60	22			
76	SAC/SAC	60	60	60	60	60	47			
79	SAC/SAC	60	60	60	60	60	60	12		
78	SAC/SAC	60	60	60	60	60	60	60	47	
75	SAC/SAC	60	60	60	60	60	60	60	60	20
114	SACB/SAC	60	60	60	60	60	60	60	2	
117	SACB/SAC	60	60	60	60	60	60	60	11	
116	SACB/SAC	60	60	60	60	60	60	60	29	
118	SACB/SAC	60	60	60	60	60	60	60	47	
115	SACB/SAC	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	15		
5	SnPb/SnPb	60	60	60	60	60	60	60	19	
9	SnPb/SnPb	60	60	60	60	60	60	60	35	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	12
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-4. BGA-225 U43 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SAC	60	60	5						
77	SAC/SAC	60	60	6						
75	SAC/SAC	60	60	10						
76	SAC/SAC	60	60	23						
78	SAC/SAC	60	60	60	10					
116	SACB/SAC	60	60	7						
114	SACB/SAC	60	60	16						
117	SACB/SAC	60	60	20						
115	SACB/SAC	60	60	32						
118	SACB/SAC	60	60	51						
6	SnPb/SnPb	60	60	54						
5	SnPb/SnPb	60	60	60	3					
8	SnPb/SnPb	60	60	60	16					
9	SnPb/SnPb	60	60	60	16					
7	SnPb/SnPb	60	60	60	20					

Table C-5. BGA-225 U55 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
75	SAC/SAC	60	60	8							
77	SAC/SAC	60	60	11							
79	SAC/SAC	60	60	13							
76	SAC/SAC	60	60	37							
78	SAC/SAC	60	60	60	13						
116	SACB/SAC	60	60	27							
114	SACB/SAC	60	60	34							
117	SACB/SAC	60	60	43							
115	SACB/SAC	60	60	60	8						
118	SACB/SAC	60	60	60	11						
8	SnPb/SnPb	60	60	60	18						
9	SnPb/SnPb	60	60	60	20						
5	SnPb/SnPb	60	60	60	60	33					
6	SnPb/SnPb	60	60	60	60	60	5				
7	SnPb/SnPb	60	60	60	60	60	20				

Table C-6. BGA-225 U2 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	60	60	52			
76	SAC/SnPb	60	60	60	60	60	60	60	15	
79	SAC/SnPb	60	60	60	60	60	60	60	60	1
78	SAC/SnPb	60	60	60	60	60	60	60	60	45
75	SAC/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	11				
117	SACB/SnPb	60	60	60	60	60	60	16		
114	SACB/SnPb	60	60	60	60	60	60	60	60	11
118	SACB/SnPb	60	60	60	60	60	60	60	60	26
115	SACB/SnPb	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	15			
6	SnPb/SnPb	60	60	60	60	60	60	60	2	
9	SnPb/SnPb	60	60	60	60	60	60	60	19	
7	SnPb/SnPb	60	60	60	60	60	60	60	54	
8	SnPb/SnPb	60	60	60	60	60	60	60	60	24

Table C-7. BGA-225 U5 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/SnPb	60	60	10						
77	SAC/SnPb	60	60	10						
79	SAC/SnPb	60	60	32						
78	SAC/SnPb	60	60	54						
76	SAC/SnPb	60	60	60	8					
116	SACB/SnPb	60	60	13						
114	SACB/SnPb	60	60	60	2					
117	SACB/SnPb	60	60	60	9					
118	SACB/SnPb	60	60	60	39					
115	SACB/SnPb	60	60	60	48					
6	SnPb/SnPb	60	60	25						
8	SnPb/SnPb	60	60	45						
7	SnPb/SnPb	60	60	60	9					
5	SnPb/SnPb	60	60	60	10					
9	SnPb/SnPb	60	60	60	60	14				

Table C-8. BGA-225 U21 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	60	5				
79	SAC/SnPb	60	60	60	60	6				
76	SAC/SnPb	60	60	60	60	60	42			
75	SAC/SnPb	60	60	60	60	60	60	34		
78	SAC/SnPb	60	60	60	60	60	60	34		
114	SACB/SnPb	60	60	60	60	29				
116	SACB/SnPb	60	60	60	60	31				
118	SACB/SnPb	60	60	60	60	60	25			
115	SACB/SnPb	60	60	60	60	60	60	60	43	
117	SACB/SnPb	60	60	60	60	60	60	60	60	5
6	SnPb/SnPb	60	60	60	60	57				
7	SnPb/SnPb	60	60	60	60	60	19			
9	SnPb/SnPb	60	60	60	60	60	60	60	5	
5	SnPb/SnPb	60	60	60	60	60	60	60	60	41
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-9. BGA-225 U44 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	6					
79	SAC/SnPb	60	60	60	16					
75	SAC/SnPb	60	60	60	23					
76	SAC/SnPb	60	60	60	43					
78	SAC/SnPb	60	60	60	60	60	16			
116	SACB/SnPb	60	60	60	9					
114	SACB/SnPb	60	60	60	27					
118	SACB/SnPb	60	60	60	60	48				
117	SACB/SnPb	60	60	60	60	49				
115	SACB/SnPb	60	60	60	60	60	43			
6	SnPb/SnPb	60	60	60	60	60	8			
8	SnPb/SnPb	60	60	60	60	60	8			
5	SnPb/SnPb	60	60	60	60	60	16			
7	SnPb/SnPb	60	60	60	60	60	19			
9	SnPb/SnPb	60	60	60	60	60	32			

Table C-10. BGA-225 U56 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	14						
75	SAC/SnPb	60	60	60	60	9				
76	SAC/SnPb	60	60	60	60	60	9			
79	SAC/SnPb	60	60	60	60	60	29			
78	SAC/SnPb	60	60	60	60	60	60	60	60	1
114	SACB/SnPb	60	60	60	60	60	60	13		
116	SACB/SnPb	60	60	60	60	60	60	42		
117	SACB/SnPb	60	60	60	60	60	60	60	5	
115	SACB/SnPb	60	60	60	60	60	60	60	32	
118	SACB/SnPb	60	60	60	60	60	60	60	60	59
9	SnPb/SnPb	60	60	60	60	60	60	60	46	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	23
8	SnPb/SnPb	60	60	60	60	60	60	60	60	44
6	SnPb/SnPb	60	60	60	60	60	60	60	60	50
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-11. CLCC-20 U10 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SAC	60	60	60	60	60	60	60	32	
76	SAC/SAC	60	60	60	60	60	60	60	36	
79	SAC/SAC	60	60	60	60	60	60	60	60	28
75	SAC/SAC	60	60	60	60	60	60	60	60	60
78	SAC/SAC	60	60	60	60	60	60	60	60	60
114	SACB/SACB	60	60	60	60	60	60	60	60	60
115	SACB/SACB	60	60	60	60	60	60	60	60	60
116	SACB/SACB	60	60	60	60	60	60	60	60	60
117	SACB/SACB	60	60	60	60	60	60	60	60	60
118	SACB/SACB	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-12. CLCC-20 U14 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SAC	60	60	31						
76	SAC/SAC	60	60	35						
79	SAC/SAC	60	60	41						
75	SAC/SAC	60	60	60	26					
78	SAC/SAC	60	60	60	60	3				
116	SACB/SACB	60	60	60	9					
115	SACB/SACB	60	60	60	60	9				
118	SACB/SACB	60	60	60	60	17				
114	SACB/SACB	60	60	60	60	20				
117	SACB/SACB	60	60	60	60	51				
6	SnPb/SnPb	60	60	60	26					
5	SnPb/SnPb	60	60	60	29					
7	SnPb/SnPb	60	60	60	60	6				
8	SnPb/SnPb	60	60	60	60	15				
9	SnPb/SnPb	60	60	60	60	33				

Table C-13. CLCC-20 U17 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SAC	60	60	60	60	60	60	60	42	
79	SAC/SAC	60	60	60	60	60	60	60	60	11
75	SAC/SAC	60	60	60	60	60	60	60	60	13
76	SAC/SAC	60	60	60	60	60	60	60	60	14
78	SAC/SAC	60	60	60	60	60	60	60	60	60
114	SACB/SACB	60	60	60	60	60	60	60	60	60
115	SACB/SACB	60	60	60	60	60	60	60	60	60
116	SACB/SACB	60	60	60	60	60	60	60	60	60
117	SACB/SACB	60	60	60	60	60	60	60	60	60
118	SACB/SACB	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-14. CLCC-20 U45 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
75	SAC/SAC	60	60	60	60	60	60	60	60	60	
76	SAC/SAC	60	60	60	60	60	60	60	60	60	
77	SAC/SAC	60	60	60	60	60	60	60	60	60	
78	SAC/SAC	60	60	60	60	60	60	60	60	60	
79	SAC/SAC	60	60	60	60	60	60	60	60	60	
116	SACB/SACB	60	60	60	60	11					
114	SACB/SACB	60	60	60	60	60	60	60	60	60	
115	SACB/SACB	60	60	60	60	60	60	60	60	60	
117	SACB/SACB	60	60	60	60	60	60	60	60	60	
118	SACB/SACB	60	60	60	60	60	60	60	60	60	
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60	

Table C-15. CLCC-20 U52 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
76	SAC/SAC	60	60	60	60	44					
79	SAC/SAC	60	60	60	60	60	17				
77	SAC/SAC	60	60	60	60	60	60	4			
78	SAC/SAC	60	60	60	60	60	60	32			
75	SAC/SAC	60	60	60	60	60	60	37			
114	SACB/SACB	60	60	60	60	60	60	26			
115	SACB/SACB	60	60	60	60	60	60	60	59		
117	SACB/SACB	60	60	60	60	60	60	60	60	14	
118	SACB/SACB	60	60	60	60	60	60	60	60	35	
116	SACB/SACB	60	60	60	60	60	60	60	60	60	
7	SnPb/SnPb	60	60	60	60	60	60	37			
9	SnPb/SnPb	60	60	60	60	60	60	60	31		
6	SnPb/SnPb	60	60	60	60	60	60	60	60	5	
8	SnPb/SnPb	60	60	60	60	60	60	60	60	21	
5	SnPb/SnPb	60	60	60	60	60	60	60	60	24	

Table C-16. CLCC-20 U9 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	60	60	60	60	60	11
76	SAC/SnPb	60	60	60	60	60	60	60	60	33
79	SAC/SnPb	60	60	60	60	60	60	60	60	42
75	SAC/SnPb	60	60	60	60	60	60	60	60	60
78	SAC/SnPb	60	60	60	60	60	60	60	60	60
114	SACB/SnPb	60	60	60	60	60	60	60	60	60
115	SACB/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	60	60	60	60
118	SACB/SnPb	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-17. CLCC-20 U13 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/SnPb	60	60	60	8					
77	SAC/SnPb	60	60	60	9					
79	SAC/SnPb	60	60	60	21					
78	SAC/SnPb	60	60	60	60	18				
75	SAC/SnPb	60	60	60	60	23				
116	SACB/SnPb	60	60	60	49					
114	SACB/SnPb	60	60	60	60	59				
117	SACB/SnPb	60	60	60	60	60	13			
118	SACB/SnPb	60	60	60	60	60	24			
115	SACB/SnPb	60	60	60	60	60	52			
5	SnPb/SnPb	60	60	60	40					
6	SnPb/SnPb	60	60	60	42					
8	SnPb/SnPb	60	60	60	43					
9	SnPb/SnPb	60	60	60	60	6				
7	SnPb/SnPb	60	60	60	60	24				

Table C-18. CLCC-20 U22 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/SnPb	60	60	60	60	60	60	60	1	
75	SAC/SnPb	60	60	60	60	60	60	60	60	60
77	SAC/SnPb	60	60	60	60	60	60	60	60	60
78	SAC/SnPb	60	60	60	60	60	60	60	60	60
79	SAC/SnPb	60	60	60	60	60	60	60	60	60
114	SACB/SnPb	60	60	60	60	60	60	60	60	60
115	SACB/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	60	60	60	60
118	SACB/SnPb	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-19. CLCC-20 U46 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	60	60	60	60	60	1
76	SAC/SnPb	60	60	60	60	60	60	60	60	4
75	SAC/SnPb	60	60	60	60	60	60	60	60	16
78	SAC/SnPb	60	60	60	60	60	60	60	60	60
79	SAC/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	11				
114	SACB/SnPb	60	60	60	60	60	60	60	60	60
115	SACB/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	60	60	60	60
118	SACB/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	40		
9	SnPb/SnPb	60	60	60	60	60	60	60	32	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	1
8	SnPb/SnPb	60	60	60	60	60	60	60	60	11
5	SnPb/SnPb	60	60	60	60	60	60	60	60	26

Table C-20. CLCC-20 U53 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
76	SAC/SnPb	60	60	60	60	60	10				
79	SAC/SnPb	60	60	60	60	60	60	26			
78	SAC/SnPb	60	60	60	60	60	60	60	11		
77	SAC/SnPb	60	60	60	60	60	60	60	26		
75	SAC/SnPb	60	60	60	60	60	60	60	29		
114	SACB/SnPb	60	60	60	60	60	60	22			
115	SACB/SnPb	60	60	60	60	60	60	60	35		
116	SACB/SnPb	60	60	60	60	60	60	60	60	9	
118	SACB/SnPb	60	60	60	60	60	60	60	60	38	
117	SACB/SnPb	60	60	60	60	60	60	60	60	60	
9	SnPb/SnPb	60	60	60	60	60	60	60	60	11	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	21	
6	SnPb/SnPb	60	60	60	60	60	60	60	60	41	
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60	

Table C-21. PDIP-20 U8 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
77	SAC/NiPdAu	60	60	5							
76	SAC/NiPdAu	60	60	60	34						
78	SAC/NiPdAu	60	60	60	60	1					
79	SAC/NiPdAu	60	60	60	60	60	3				
75	SAC/NiPdAu	60	60	60	60	60	60	60	18		
115	SnCu/NiPdAu	60	60	60	60	60	27				
114	SnCu/NiPdAu	60	60	60	60	60	60	60	26		
116	SnCu/NiPdAu	60	60	60	60	60	60	60	28		
117	SnCu/NiPdAu	60	60	60	60	60	60	60	60	1	
118	SnCu/NiPdAu	60	60	60	60	60	60	60	60	17	
8	SnPb/NiPdAu	60	60	14							
5	SnPb/NiPdAu	60	60	20							
6	SnPb/NiPdAu	60	60	20							
7	SnPb/NiPdAu	60	60	22							
9	SnPb/NiPdAu	60	60	60	8						

Table C-22. PDIP-20 U23 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
76	SAC/NiPdAu	60	60	60	60	60	55			
77	SAC/NiPdAu	60	60	60	60	60	60	44		
75	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
78	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
79	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
114	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
115	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
116	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
117	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
118	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
5	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
6	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
7	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
8	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
9	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60

Table C-23. PDIP-20 U35 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/NiPdAu	bad part								
79	SAC/NiPdAu	60	60	60	60	17				
77	SAC/NiPdAu	60	60	60	60	60				
78	SAC/NiPdAu	60	60	60	60	60	22			
75	SAC/NiPdAu	60	60	60	60	60	41			
117	SnCu/NiPdAu	60	60	60	60	60	60	60	56	
115	SnCu/NiPdAu	60	60	60	60	60	60	60	60	1
116	SnCu/NiPdAu	60	60	60	60	60	60	60	60	18
114	SnCu/NiPdAu	60	60	60	60	60	60	60	60	40
118	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
8	SnPb/NiPdAu	60	60	10						
5	SnPb/NiPdAu	60	60	11						
9	SnPb/NiPdAu	60	60	60	7					
6	SnPb/NiPdAu	60	60	60	51					
7	SnPb/NiPdAu	60	60	60	60	8				

Table C-24. PDIP-20 U49 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/NiPdAu	60	60	19						
76	SAC/NiPdAu	60	60	26						
75	SAC/NiPdAu	60	60	45						
79	SAC/NiPdAu	60	60	60	60	17				
78	SAC/NiPdAu	60	60	60	60	49				
116	SnCu/NiPdAu	60	60	60	60	60	43			
118	SnCu/NiPdAu	60	60	60	60	60	60	60	13	
115	SnCu/NiPdAu	60	60	60	60	60	60	60	33	
117	SnCu/NiPdAu	60	60	60	60	60	60	60	60	21
114	SnCu/NiPdAu	60	60	60	60	60	60	60	60	24
5	SnPb/NiPdAu	bad part								
9	SnPb/NiPdAu	60	60	12						
8	SnPb/NiPdAu	60	60	25						
7	SnPb/NiPdAu	60	60	36						
6	SnPb/NiPdAu	60	60	60	12					

Table C-25. PDIP-20 U59 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
77	SAC/NiPdAu	60	60	60	60	60	60	60	17	
75	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
76	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
78	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
79	SAC/NiPdAu	60	60	60	60	60	60	60	60	60
114	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
115	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
116	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
117	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
118	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
8	SnPb/NiPdAu	60	60	60	60	60	60	60	60	16
5	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
6	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
7	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
9	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60

Table C-26. PDIP-20 U11 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/Sn	60	60	45						
76	SAC/Sn	60	60	60	38					
79	SAC/Sn	60	60	60	60	50				
78	SAC/Sn	60	60	60	60	60	54			
75	SAC/Sn	60	60	60	60	60	60	14		
117	SnCu/Sn	60	60	60	60	60	60	14		
116	SnCu/Sn	60	60	60	60	60	60	60	25	
118	SnCu/Sn	60	60	60	60	60	60	60	36	
115	SnCu/Sn	60	60	60	60	60	60	60	60	30
114	SnCu/Sn	60	60	60	60	60	60	60	60	33
5	SnPb/Sn	60	60	60	60	43				
8	SnPb/Sn	60	60	60	60	52				
9	SnPb/Sn	60	60	60	60	60	46			
6	SnPb/Sn	60	60	60	60	60	60	13		
7	SnPb/Sn	60	60	60	60	60	60	32		

Table C-27. PDIP-20 U30 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/Sn	60	60	60	20					
79	SAC/Sn	60	60	60	60	60	32			
78	SAC/Sn	60	60	60	60	60	59			
75	SAC/Sn	60	60	60	60	60	60	60	38	
76	SAC/Sn	60	60	60	60	60	60	60	60	60
117	SnCu/Sn	60	60	60	60	60	41			
118	SnCu/Sn	60	60	60	60	60	60	4		
116	SnCu/Sn	60	60	60	60	60	60	6		
115	SnCu/Sn	60	60	60	60	60	60	60	32	
114	SnCu/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	22			
9	SnPb/Sn	60	60	60	60	60	60	10		
5	SnPb/Sn	60	60	60	60	60	60	52		
6	SnPb/Sn	60	60	60	60	60	60	60	60	20
7	SnPb/Sn	60	60	60	60	60	60	60	60	44

Table C-28. PDIP-20 U38 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/Sn	60	60	60	60	42				
79	SAC/Sn	60	60	60	60	60	39			
76	SAC/Sn	60	60	60	60	60	60	60	27	
75	SAC/Sn	60	60	60	60	60	60	60	60	14
78	SAC/Sn	60	60	60	60	60	60	60	60	18
117	SnCu/Sn	60	60	60	60	60	48			
118	SnCu/Sn	60	60	60	60	60	60	13		
116	SnCu/Sn	60	60	60	60	60	60	17		
115	SnCu/Sn	60	60	60	60	60	60	60	60	19
114	SnCu/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	26				
7	SnPb/Sn	60	60	60	60	57				
5	SnPb/Sn	60	60	60	60	58				
8	SnPb/Sn	60	60	60	60	60	22			
9	SnPb/Sn	60	60	60	60	60	60	60	48	

Table C-29. PDIP-20 U51 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/Sn	60	60	60	2					
76	SAC/Sn	60	60	60	19					
75	SAC/Sn	60	60	60	60	60	60	11		
78	SAC/Sn	60	60	60	60	60	60	60	15	
79	SAC/Sn	60	60	60	60	60	60	60	27	
115	SnCu/Sn	60	60	60	60	60	60	60	39	
118	SnCu/Sn	60	60	60	60	60	60	60	60	51
117	SnCu/Sn	60	60	60	60	60	60	60	60	59
114	SnCu/Sn	60	60	60	60	60	60	60	60	60
116	SnCu/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	1		
7	SnPb/Sn	60	60	60	60	60	60	24		
9	SnPb/Sn	60	60	60	60	60	60	10		
6	SnPb/Sn	60	60	60	60	60	60	60	41	
5	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table C-30. PDIP-20 U63 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/Sn	60	60	8						
77	SAC/Sn	60	60	60	22					
79	SAC/Sn	60	60	60	60	49				
78	SAC/Sn	60	60	60	60	60	60	14		
75	SAC/Sn	60	60	60	60	60	60	60	21	
117	SnCu/Sn	60	60	60	60	30				
116	SnCu/Sn	60	60	60	60	60	1			
114	SnCu/Sn	60	60	60	60	60	49			
118	SnCu/Sn	60	60	60	60	60	60	48		
115	SnCu/Sn	60	60	60	60	60	60	60	35	
7	SnPb/Sn	60	60	60	60	16				
8	SnPb/Sn	60	60	60	60	36				
5	SnPb/Sn	60	60	60	60	57				
9	SnPb/Sn	60	60	60	60	60	45			
6	SnPb/Sn	60	60	60	60	60	57			

Table C-31. TSOP-20 U12 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SnCu	60	60	60	49					
77	SAC/SnCu	60	60	60	60	60	4			
78	SAC/SnCu	60	60	60	60	60	38			
75	SAC/SnCu	60	60	60	60	60	39			
76	SAC/SnCu	60	60	60	60	60	60	39		
116	SACB/SnCu	60	60	60	60	11				
114	SACB/SnCu	60	60	60	60	34				
118	SACB/SnCu	60	60	60	60	41				
117	SACB/SnCu	60	60	60	60	60	51			
115	SACB/SnCu	60	60	60	60	60	53			
8	SnPb/SnPb	60	60	60	60	22				
7	SnPb/SnPb	60	60	60	60	58				
9	SnPb/SnPb	60	60	60	60	60	60	60	60	6
5	SnPb/SnPb	60	60	60	60	60	60	60	60	13
6	SnPb/SnPb	60	60	60	60	60	60	60	60	33

Table C-32. TSOP-20 U25 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SnCu	60	60	60	60	22				
75	SAC/SnCu	60	60	60	60	60	19			
78	SAC/SnCu	60	60	60	60	60	60	5		
76	SAC/SnCu	60	60	60	60	60	60	26		
77	SAC/SnCu	60	60	60	60	60	60	30		
115	SACB/SnCu	60	60	60	60	7				
116	SACB/SnCu	60	60	60	60	11				
114	SACB/SnCu	60	60	60	60	60	24			
117	SACB/SnCu	60	60	60	60	60	25			
118	SACB/SnCu	60	60	60	60	60	60	3		
8	SnPb/SnPb	60	60	60	23					
5	SnPb/SnPb	60	60	60	60	14				
7	SnPb/SnPb	60	60	60	60	48				
6	SnPb/SnPb	60	60	60	60	51				
9	SnPb/SnPb	60	60	60	60	60	60	60	3	

Table C-33. TSOP-20 U29 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms	
77	SAC/SnCu	60	60	60	60	60	60	60	25		
75	SAC/SnCu	60	60	60	60	60	60	60	60	60	
76	SAC/SnCu	60	60	60	60	60	60	60	60	60	
78	SAC/SnCu	60	60	60	60	60	60	60	60	60	
79	SAC/SnCu	60	60	60	60	60	60	60	60	60	
117	SACB/SnCu	60	60	60	60	60	60	60	60	4	
118	SACB/SnCu	60	60	60	60	60	60	60	60	22	
114	SACB/SnCu	60	60	60	60	60	60	60	60	60	
115	SACB/SnCu	60	60	60	60	60	60	60	60	60	
116	SACB/SnCu	60	60	60	60	60	60	60	60	60	
9	SnPb/SnPb	60	60	60	60	60	60	30			
6	SnPb/SnPb	60	60	60	60	60	60	60	40		
7	SnPb/SnPb	60	60	60	60	60	60	60	53		
8	SnPb/SnPb	60	60	60	60	60	60	60	56		
5	SnPb/SnPb	60	60	60	60	60	60	60	59		

Table C-34. TSOP-20 U39 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/SnCu	60	60	60	60	60	60	60	60	60
76	SAC/SnCu	60	60	60	60	60	60	60	60	60
77	SAC/SnCu	60	60	60	60	60	60	60	60	60
78	SAC/SnCu	60	60	60	60	60	60	60	60	60
79	SAC/SnCu	60	60	60	60	60	60	60	60	60
114	SACB/SnCu	60	60	60	60	60	60	60	60	60
115	SACB/SnCu	60	60	60	60	60	60	60	60	60
116	SACB/SnCu	60	60	60	60	60	60	60	60	60
117	SACB/SnCu	60	60	60	60	60	60	60	60	60
118	SACB/SnCu	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-35. TSOP-20 U61 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SnCu	60	60	60	60	60	60	60	60	1
78	SAC/SnCu	60	60	60	60	60	60	60	60	41
75	SAC/SnCu	60	60	60	60	60	60	60	60	60
76	SAC/SnCu	60	60	60	60	60	60	60	60	60
77	SAC/SnCu	60	60	60	60	60	60	60	60	60
115	SACB/SnCu	60	60	60	60	60	60	60	33	
114	SACB/SnCu	60	60	60	60	60	60	60	60	60
116	SACB/SnCu	60	60	60	60	60	60	60	60	60
117	SACB/SnCu	60	60	60	60	60	60	60	60	60
118	SACB/SnCu	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	28
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-36. TSOP-20 U16 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/SnPb	60	60	60	60	60	60	47		
79	SAC/SnPb	60	60	60	60	60	60	60	60	13
75	SAC/SnPb	60	60	60	60	60	60	60	60	50
76	SAC/SnPb	60	60	60	60	60	60	60	60	60
78	SAC/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	2			
115	SACB/SnPb	60	60	60	60	60	60	19		
118	SACB/SnPb	60	60	60	60	60	60	29		
114	SACB/SnPb	60	60	60	60	60	60	51		
116	SACB/SnPb	60	60	60	60	60	60	60	60	24
8	SnPb/SnPb	60	60	60	60	60	60	60	24	
5	SnPb/SnPb	60	60	60	60	60	60	60	27	
7	SnPb/SnPb	60	60	60	60	60	60	60	60	7
9	SnPb/SnPb	60	60	60	60	60	60	60	60	8
6	SnPb/SnPb	60	60	60	60	60	60	60	60	13

Table C-37. TSOP-20 U24 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
78	SAC/SnPb	60	60	60	60	60	28			
76	SAC/SnPb	60	60	60	60	60	29			
79	SAC/SnPb	60	60	60	60	60	33			
77	SAC/SnPb	60	60	60	60	60	39			
75	SAC/SnPb	60	60	60	60	60	48			
115	SACB/SnPb	60	60	60	60	60	5			
114	SACB/SnPb	60	60	60	60	60	31			
118	SACB/SnPb	60	60	60	60	60	51			
117	SACB/SnPb	60	60	60	60	60	60	13		
116	SACB/SnPb	60	60	60	60	60	60	38		
5	SnPb/SnPb	60	60	60	60	53				
8	SnPb/SnPb	60	60	60	60	54				
7	SnPb/SnPb	60	60	60	60	60	1			
6	SnPb/SnPb	60	60	60	60	60	25			
9	SnPb/SnPb	60	60	60	60	60	60	1		

Table C-38. TSOP-20 U26 (“Manufactured” PWA’s

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/SnPb	60	60	60	60	17				
77	SAC/SnPb	60	60	60	60	60	13			
76	SAC/SnPb	60	60	60	60	60	60	6		
75	SAC/SnPb	60	60	60	60	60	60	16		
78	SAC/SnPb	60	60	60	60	60	60	21		
115	SACB/SnPb	60	60	60	23					
114	SACB/SnPb	60	60	60	60	1				
116	SACB/SnPb	60	60	60	60	15				
118	SACB/SnPb	60	60	60	60	20				
117	SACB/SnPb	60	60	60	60	46				
5	SnPb/SnPb	60	60	60	60	60	60	60	60	43
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-39. TSOP-20 U40 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
78	SAC/SnPb	60	60	60	60	60	60	60	60	5
77	SAC/SnPb	60	60	60	60	60	60	60	60	27
75	SAC/SnPb	60	60	60	60	60	60	60	60	60
76	SAC/SnPb	60	60	60	60	60	60	60	60	60
79	SAC/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	11				
115	SACB/SnPb	60	60	60	60	60	60	60	60	38
114	SACB/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	60	60	60	60
118	SACB/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	10	
5	SnPb/SnPb	60	60	60	60	60	60	60	60	4
8	SnPb/SnPb	60	60	60	60	60	60	60	60	9
7	SnPb/SnPb	60	60	60	60	60	60	60	60	13
9	SnPb/SnPb	60	60	60	60	60	60	60	60	28

Table C-40. TSOP-20 U62 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/SnPb	60	60	60	60	60	60	60	60	60
76	SAC/SnPb	60	60	60	60	60	60	60	60	60
77	SAC/SnPb	60	60	60	60	60	60	60	60	60
78	SAC/SnPb	60	60	60	60	60	60	60	60	60
79	SAC/SnPb	60	60	60	60	60	60	60	60	60
115	SACB/SnPb	60	60	60	60	60	60	60	60	42
114	SACB/SnPb	60	60	60	60	60	60	60	60	60
116	SACB/SnPb	60	60	60	60	60	60	60	60	60
117	SACB/SnPb	60	60	60	60	60	60	60	60	60
118	SACB/SnPb	60	60	60	60	60	60	60	60	60
5	SnPb/SnPb	60	60	60	60	60	60	60	60	60
6	SnPb/SnPb	60	60	60	60	60	60	60	60	60
7	SnPb/SnPb	60	60	60	60	60	60	60	60	60
8	SnPb/SnPb	60	60	60	60	60	60	60	60	60
9	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table C-41. PLCC-20 U15 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/Sn	60	60	60	9					
75	SAC/Sn	60	60	60	31					
79	SAC/Sn	60	60	60	56					
77	SAC/Sn	60	60	60	60	29				
78	SAC/Sn	60	60	60	60	36				
116	SACB/Sn	60	60	60	24					
114	SACB/Sn	60	60	60	46					
118	SACB/Sn	60	60	60	60	38				
115	SACB/Sn	60	60	60	60	60	15			
117	SACB/Sn	60	60	60	60	60	60	10		
7	SnPb/Sn	60	60	60	60	50				
9	SnPb/Sn	60	60	60	60	60	11			
8	SnPb/Sn	60	60	60	60	60	14			
6	SnPb/Sn	60	60	60	60	60	24			
5	SnPb/Sn	60	60	60	60	60	60	60	60	17

Table C-42. PLCC-20 U27 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/Sn	60	60	60	60	60	60	60	60	60
76	SAC/Sn	60	60	60	60	60	60	60	60	60
77	SAC/Sn	60	60	60	60	60	60	60	60	60
78	SAC/Sn	60	60	60	60	60	60	60	60	60
79	SAC/Sn	60	60	60	60	60	60	60	60	60
114	SACB/Sn	60	60	60	60	60	60	60	60	60
115	SACB/Sn	60	60	60	60	60	60	60	60	60
116	SACB/Sn	60	60	60	60	60	60	60	60	60
117	SACB/Sn	60	60	60	60	60	60	60	60	60
118	SACB/Sn	60	60	60	60	60	60	60	60	60
5	SnPb/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	60	60	60	60	60
7	SnPb/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	60	60	60
9	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table C-43. PLCC-20 U28 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/Sn	60	60	60	60	60	60	60	60	60
76	SAC/Sn	60	60	60	60	60	60	60	60	60
77	SAC/Sn	60	60	60	60	60	60	60	60	60
78	SAC/Sn	60	60	60	60	60	60	60	60	60
79	SAC/Sn	60	60	60	60	60	60	60	60	60
114	SACB/Sn	60	60	60	60	60	60	60	60	60
115	SACB/Sn	60	60	60	60	60	60	60	60	60
116	SACB/Sn	60	60	60	60	60	60	60	60	60
117	SACB/Sn	60	60	60	60	60	60	60	60	60
118	SACB/Sn	60	60	60	60	60	60	60	60	60
5	SnPb/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	60	60	60	60	60
7	SnPb/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	60	60	60
9	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table C-44. PLCC-20 U47 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/Sn	60	60	60	60	60	60	60	60	27
75	SAC/Sn	60	60	60	60	60	60	60	60	40
76	SAC/Sn	60	60	60	60	60	60	60	60	46
77	SAC/Sn	60	60	60	60	60	60	60	60	60
78	SAC/Sn	60	60	60	60	60	60	60	60	60
114	SACB/Sn	60	60	60	60	60	60	60	60	60
115	SACB/Sn	60	60	60	60	60	60	60	60	60
116	SACB/Sn	60	60	60	60	60	60	60	60	60
117	SACB/Sn	60	60	60	60	60	60	60	60	60
118	SACB/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	60	60	60	60	10
9	SnPb/Sn	60	60	60	60	60	60	60	60	35
5	SnPb/Sn	60	60	60	60	60	60	60	60	60
7	SnPb/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table C-45. PLCC-20 U54 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
76	SAC/Sn	60	60	60	60	60	60	60	34		
75	SAC/Sn	60	60	60	60	60	60	60	60	60	
77	SAC/Sn	60	60	60	60	60	60	60	60	60	
78	SAC/Sn	60	60	60	60	60	60	60	60	60	
79	SAC/Sn	60	60	60	60	60	60	60	60	60	
114	SACB/Sn	60	60	60	60	60	60	60	60	60	
115	SACB/Sn	60	60	60	60	60	60	60	60	60	
116	SACB/Sn	60	60	60	60	60	60	60	60	60	
117	SACB/Sn	60	60	60	60	60	60	60	60	60	
118	SACB/Sn	60	60	60	60	60	60	60	60	60	
5	SnPb/Sn	60	60	60	60	60	60	60	60	60	
6	SnPb/Sn	60	60	60	60	60	60	60	60	60	
7	SnPb/Sn	60	60	60	60	60	60	60	60	60	
8	SnPb/Sn	60	60	60	60	60	60	60	60	60	
9	SnPb/Sn	60	60	60	60	60	60	60	60	60	

Table C-46. TQFP-144 U1 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/Sn	60	60	60	60	60	60	60	46	
79	SAC/Sn	60	60	60	60	60	60	60	60	3*
77	SAC/Sn	60	60	60	60	60	60	60	60	17*
76	SAC/Sn	60	60	60	60	60	60	60	60	60
78	SAC/Sn	60	60	60	60	60	60	60	60	60*
118	SACB/Sn	60	60	60	60	60	60	46*		
114	SACB/Sn	60	60	60	60	60	60	60	60	23*
115	SACB/Sn	60	60	60	60	60	60	60	60	34
116	SACB/Sn	60	60	60	60	60	60	60	60	60
117	SACB/Sn	60	60	60	60	60	60	60	60	60
5	SnPb/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	60	60	60	60	60
7	SnPb/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	60	60	60
9	SnPb/Sn	60	60	60	60	60	60	60	60	60

*Broken or cracked leads.

Table C-47. TQFP-144 U7 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC/Sn	60	60	60	60	60	60	60	60	60
76	SAC/Sn	60	60	60	60	60	60	60	60	60
77	SAC/Sn	60	60	60	60	60	60	60	60	60*
78	SAC/Sn	60	60	60	60	60	60	60	60	60
79	SAC/Sn	60	60	60	60	60	60	60	60	60
114	SACB/Sn	60	60	60	60	60	60	60	60	60
115	SACB/Sn	60	60	60	60	60	60	60	60	60
116	SACB/Sn	60	60	60	60	60	60	60	60	60
117	SACB/Sn	60	60	60	60	60	60	60	60	60
118	SACB/Sn	60	60	60	60	60	60	60	60	60
5	SnPb/Sn	60	60	60	60	60	60	60	60	60
6	SnPb/Sn	60	60	60	60	60	60	60	60	60*
7	SnPb/Sn	60	60	60	60	60	60	60	60	60
8	SnPb/Sn	60	60	60	60	60	60	60	60	60
9	SnPb/Sn	60	60	60	60	60	60	60	60	60

*Broken or cracked leads.

Table C-48. TQFP-144 U20 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
79	SAC/Sn	60	60	60	27*						
77	SAC/Sn	60	60	60	60	14*					
75	SAC/Sn	60	60	60	60	48*					
76	SAC/Sn	60	60	60	60	57*					
78	SAC/Sn	60	60	60	60	60	15*				
115	SACB/Sn	60	60	60	60	11*					
114	SACB/Sn	60	60	60	60	32*					
118	SACB/Sn	60	60	60	60	35*					
116	SACB/Sn	60	60	60	60	38*					
117	SACB/Sn	60	60	60	60	60	50*				
5	SnPb/Sn	60	60	60	60	48*					
6	SnPb/Sn	60	60	60	60	60	16*				
7	SnPb/Sn	60	60	60	60	60	34*				
8	SnPb/Sn	60	60	60	60	60	36*				
9	SnPb/Sn	60	60	60	60	60	43*				

*Broken or cracked leads.

Table C-49. TQFP-144 U41 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
79	SAC/Sn	60	60	60	60	52*					
77	SAC/Sn	60	60	60	60	60	47*				
75	SAC/Sn	60	60	60	60	60	60	5*			
76	SAC/Sn	60	60	60	60	60	60	44*			
78	SAC/Sn	60	60	60	60	60	60	60	1*		
115	SACB/Sn	60	60	60	60	60	35*				
118	SACB/Sn	60	60	60	60	60	56*				
114	SACB/Sn	60	60	60	60	60	59*				
117	SACB/Sn	60	60	60	60	60	60	42			
116	SACB/Sn	60	60	60	60	60	60	53*			
8	SnPb/Sn	60	60	60	60	60	60	60	16*		
7	SnPb/Sn	60	60	60	60	60	60	60	60	4*	
9	SnPb/Sn	60	60	60	60	60	60	60	60	49*	
5	SnPb/Sn	60	60	60	60	60	60	60	60	60	
6	SnPb/Sn	60	60	60	60	60	60	60	60	60*	

*Broken or cracked leads.

Table C-50. TQFP-144 U58 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
79	SAC/Sn	60	60	60	35*					
77	SAC/Sn	60	60	60	60	13*				
78	SAC/Sn	60	60	60	60	27*				
76	SAC/Sn	60	60	60	60	28*				
75	SAC/Sn	60	60	60	60	36*				
115	SACB/Sn	60	60	60	34*					
114	SACB/Sn	60	60	60	44					
118	SACB/Sn	60	60	60	60	3*				
116	SACB/Sn	60	60	60	60	11*				
117	SACB/Sn	60	60	60	60	54*				
7	SnPb/Sn	60	60	60	56*					
5	SnPb/Sn	60	60	60	60	7*				
8	SnPb/Sn	60	60	60	60	19*				
6	SnPb/Sn	60	60	60	60	52*				
9	SnPb/Sn	60	60	60	60	60	27*			

***Broken or cracked leads.**

Table C-51. TQFP-208 U3 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
79	SAC/NiPdAu	60	60	34*							
77	SAC/NiPdAu	60	60	40*							
75	SAC/NiPdAu	60	60	55*							
78	SAC/NiPdAu	60	60	60	16*						
76	SAC/NiPdAu	60	60	60	26*						
116	SACB/NiPdAu	60	60	47*							
117	SACB/NiPdAu	60	60	51*							
118	SACB/NiPdAu	60	60	60	4*						
114	SACB/NiPdAu	60	60	60	13*						
115	SACB/NiPdAu	60	60	60	18*						
5	SnPb/NiPdAu	60	60	41*							
6	SnPb/NiPdAu	60	60	41*							
8	SnPb/NiPdAu	60	60	42*							
7	SnPb/NiPdAu	60	60	57*							
9	SnPb/NiPdAu	60	60	60	5*						

***Broken or cracked leads.**

Table C-52 TQFP-208 U31 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
77	SAC/NiPdAu	60	60	60	60	60	60	60	33*	
75	SAC/NiPdAu	60	60	60	60	60	60	60	49	
78	SAC/NiPdAu	60	60	60	60	60	60	60	60	9*
76	SAC/NiPdAu	60	60	60	60	60	60	60	60	13*
79	SAC/NiPdAu	60	60	60	60	60	60	60	60	15
114	SACB/NiPdAu	60	60	60	60	60	60	60	60	8
118	SACB/NiPdAu	60	60	60	60	60	60	60	60	13
115	SACB/NiPdAu	60	60	60	60	60	60	60	60	14
117	SACB/NiPdAu	60	60	60	60	60	60	60	60	17
116	SACB/NiPdAu	60	60	60	60	60	60	60	60	28
6	SnPb/NiPdAu	60	60	60	60	60	60	60	4*	
5	SnPb/NiPdAu	60	60	60	60	60	60	60	22	
9	SnPb/NiPdAu	60	60	60	60	60	60	60	14*	
7	SnPb/NiPdAu	60	60	60	60	60	60	60	51	
8	SnPb/NiPdAu	60	60	60	60	60	60	60	60	11

*Broken or cracked leads.

Table C-53. TQFP-208 U34 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
79	SAC/NiPdAu	60	60	60	60	52*					
78	SAC/NiPdAu	60	60	60	60	60	60	1*			
76	SAC/NiPdAu	60	60	60	60	60	60	13*			
77	SAC/NiPdAu	60	60	60	60	60	60	25*			
75	SAC/NiPdAu	60	60	60	60	60	60	34*			
118	SACB/NiPdAu	bad part									
114	SACB/NiPdAu	60	60	60	60	52					
115	SACB/NiPdAu	60	60	60	60	60	30*				
116	SACB/NiPdAu	60	60	60	60	60	60	53*			
117	SACB/NiPdAu	60	60	60	60	60	60	60	60	3*	
7	SnPb/NiPdAu	60	60	60	60	60	60	60	32		
5	SnPb/NiPdAu	60	60	60	60	60	60	60	38		
8	SnPb/NiPdAu	60	60	60	60	60	60	60	59*		
9	SnPb/NiPdAu	60	60	60	60	60	60	60	60	6*	
6	SnPb/NiPdAu	60	60	60	60	60	60	60	60	10	

*Broken or cracked leads.

Table C-54. TQFP-208 U48 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
76	SAC/NiPdAu	60	60	60	60	60	60	60	4*	
77	SAC/NiPdAu	60	60	60	60	60	60	60	4*	
79	SAC/NiPdAu	60	60	60	60	60	60	60	14*	
78	SAC/NiPdAu	60	60	60	60	60	60	60	32*	
75	SAC/NiPdAu	60	60	60	60	60	60	60	50*	
114	SACB/NiPdAu	60	60	60	60	60	60	3*		
115	SACB/NiPdAu	60	60	60	60	60	60	50*		
118	SACB/NiPdAu	60	60	60	60	60	60	60	33*	
116	SACB/NiPdAu	60	60	60	60	60	60	60	41*	
117	SACB/NiPdAu	60	60	60	60	60	60	60	60	33
7	SnPb/NiPdAu	60	60	60	60	60	60	60	60	19
5	SnPb/NiPdAu	60	60	60	60	60	60	60	60	25
8	SnPb/NiPdAu	60	60	60	60	60	60	60	60	29
9	SnPb/NiPdAu	60	60	60	60	60	60	60	60	31*
6	SnPb/NiPdAu	60	60	60	60	60	60	60	60	38*

***Broken or cracked leads.**

Table C-55. TQFP-208 U57 (“Manufactured” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
77	SAC/NiPdAu	60	60	60	28*						
79	SAC/NiPdAu	60	60	60	31*						
75	SAC/NiPdAu	60	60	60	38*						
76	SAC/NiPdAu	60	60	60	60	6*					
78	SAC/NiPdAu	60	60	60	60	18*					
114	SACB/NiPdAu	bad part									
117	SACB/NiPdAu	60	60	60	43*						
115	SACB/NiPdAu	60	60	60	44*						
116	SACB/NiPdAu	60	60	60	50*						
118	SACB/NiPdAu	60	60	60	60	34*					
5	SnPb/NiPdAu	60	60	60	15*						
8	SnPb/NiPdAu	60	60	60	24*						
6	SnPb/NiPdAu	60	60	60	28*						
7	SnPb/NiPdAu	60	60	60	44*						
9	SnPb/NiPdAu	60	60	60	49*						

***Broken or cracked leads.**

Table C-56. Plated Through Holes (“Manufactured” PWA’s, 16.0 mils as drilled)

Test Vehicle ID	Solder Fill	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
75	SAC	60	60	60	60	60	60	60	60	60
76	SAC	60	60	60	60	60	60	60	60	60
77	SAC	60	60	60	60	60	60	60	60	60
78	SAC	60	60	60	60	60	60	60	60	60
79	SAC	60	60	60	60	60	60	60	60	60
114	SnCu	60	60	60	60	60	60	60	60	60
115	SnCu	60	60	60	60	60	60	60	60	60
116	SnCu	60	60	60	60	60	60	60	60	60
117	SnCu	60	60	60	60	60	60	60	60	60
118	SnCu	60	60	60	60	60	60	60	60	60
5	SnPb	60	60	60	60	60	60	60	60	60
6	SnPb	60	60	60	60	60	60	60	60	60
7	SnPb	60	60	60	60	60	60	60	60	60
8	SnPb	60	60	60	60	60	60	60	60	60
9	SnPb	60	60	60	60	60	60	60	60	60

Appendix D. Test Data (“Rework” PWA’s)

Table D-1. BGA-225 U4 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	flux only/SAC	60	60	3						
153	flux only/SAC	60	60	4						
185	flux only/SAC	60	60	4						
183	flux only/SAC	60	60	5						
154	flux only/SAC	60	60	6						
155	flux only/SAC	60	60	6						
156	flux only/SAC	60	60	6						
157	flux only/SAC	60	60	7						
182	flux only/SAC	60	60	8						
184	flux only/SAC	60	60	10						
50	flux only/SnPb	60	60	6						
49	flux only/SnPb	60	60	8						
43	flux only/SnPb	60	60	17						
46	flux only/SnPb	60	60	19						
47	flux only/SnPb	60	60	22						

This part was reworked.

Table D-2. BGA-225 U18 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
155	flux only/SAC	60	60	60	33					
180	flux only/SAC	60	60	60	43					
153	flux only/SAC	60	60	60	60	15				
154	flux only/SAC	60	60	60	60	18				
157	flux only/SAC	60	60	60	60	23				
185	flux only/SAC	60	60	60	60	35				
156	flux only/SAC	60	60	60	60	38				
183	flux only/SAC	60	60	60	60	58				
182	flux only/SAC	60	60	60	60	60	1			
184	flux only/SAC	60	60	60	60	60	3			
50	flux only/SnPb	60	60	60	60	3				
43	flux only/SnPb	60	60	60	60	10				
47	flux only/SnPb	60	60	60	60	19				
49	flux only/SnPb	60	60	60	60	60	11			
46	flux only/SnPb	60	60	60	60	60	60	10		

This part was reworked.

Table D-3. BGA-225 U2 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SAC	60	60	60	60	60	3			
180	SnPb/SAC	60	60	60	60	60	19			
154	SnPb/SAC	60	60	60	60	60	22			
155	SnPb/SAC	60	60	60	60	60	32			
157	SnPb/SAC	60	60	60	60	60	37			
184	SnPb/SAC	60	60	60	60	60	60	11		
182	SnPb/SAC	60	60	60	60	60	60	20		
183	SnPb/SAC	60	60	60	60	60	60	60	6	
156	SnPb/SAC	60	60	60	60	60	60	60	16	
185	SnPb/SAC	60	60	60	60	60	60	60	17	
43	SnPb/SnPb	60	60	60	60	51				
47	SnPb/SnPb	60	60	60	60	60	60	12		
50	SnPb/SnPb	60	60	60	60	60	60	26		
46	SnPb/SnPb	60	60	60	60	60	60	60	60	14
49	SnPb/SnPb	60	60	60	60	60	60	60	60	19

Table D-4. BGA-225 U5 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/SAC	60	60	6						
153	SnPb/SAC	60	60	8						
156	SnPb/SAC	60	60	8						
155	SnPb/SAC	60	60	9						
157	SnPb/SAC	60	60	10						
183	SnPb/SAC	60	60	11						
185	SnPb/SAC	60	60	11						
154	SnPb/SAC	60	60	13						
184	SnPb/SAC	60	60	13						
182	SnPb/SAC	60	60	18						
50	SnPb/SnPb	60	60	30						
47	SnPb/SnPb	60	60	59						
43	SnPb/SnPb	60	60	60	5					
49	SnPb/SnPb	60	60	60	15					
46	SnPb/SnPb	60	60	60	27					

Table D-5. BGA-225 U6 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
155	SnPb/SAC	60	60	60	35					
156	SnPb/SAC	60	60	60	39					
153	SnPb/SAC	60	60	60	60	18				
154	SnPb/SAC	60	60	60	60	31				
180	SnPb/SAC	60	60	60	60	33				
185	SnPb/SAC	60	60	60	60	48				
184	SnPb/SAC	60	60	60	60	60	60	9		
183	SnPb/SAC	60	60	60	60	60	60	10		
182	SnPb/SAC	60	60	60	60	60	60	60	18	
157	SnPb/SAC	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	33		
47	SnPb/SnPb	60	60	60	60	60	60	53		
46	SnPb/SnPb	60	60	60	60	60	60	60	2	
43	SnPb/SnPb	60	60	60	60	60	60	60	13	
50	SnPb/SnPb	60	60	60	60	60	60	60	60	16

Table D-6. BGA-225 U21 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
154	SnPb/SAC	60	60	60	54					
183	SnPb/SAC	60	60	60	60	31				
153	SnPb/SAC	60	60	60	60	35				
185	SnPb/SAC	60	60	60	60	39				
155	SnPb/SAC	60	60	60	60	44				
180	SnPb/SAC	60	60	60	60	54				
157	SnPb/SAC	60	60	60	60	60	9			
156	SnPb/SAC	60	60	60	60	60	24			
182	SnPb/SAC	60	60	60	60	60	60	8		
184	SnPb/SAC	60	60	60	60	60	60	34		
47	SnPb/SnPb	60	60	60	60	60	60	59		
46	SnPb/SnPb	60	60	60	60	60	60	60	60	1
49	SnPb/SnPb	60	60	60	60	60	60	60	60	5
50	SnPb/SnPb	60	60	60	60	60	60	60	60	38
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-7. BGA-225 U43 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
180	SnPb/SAC	60	60	39						
157	SnPb/SAC	60	60	41						
182	SnPb/SAC	60	60	44						
183	SnPb/SAC	60	60	44						
156	SnPb/SAC	60	60	46						
154	SnPb/SAC	60	60	49						
155	SnPb/SAC	60	60	51						
185	SnPb/SAC	60	60	52						
184	SnPb/SAC	60	60	60	6					
153	SnPb/SAC	60	60	60	18					
49	SnPb/SnPb	60	60	60	21					
50	SnPb/SnPb	60	60	60	25					
46	SnPb/SnPb	60	60	60	30					
47	SnPb/SnPb	60	60	60	34					
43	SnPb/SnPb	60	60	60	60	55				

Table D-8. BGA-225 U44 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
157	SnPb/SAC	60	60	60	60					
184	SnPb/SAC	60	60	60	60	7				
155	SnPb/SAC	60	60	60	60	10				
182	SnPb/SAC	60	60	60	60	21				
154	SnPb/SAC	60	60	60	60	29				
183	SnPb/SAC	60	60	60	60	29				
185	SnPb/SAC	60	60	60	60	60	11			
156	SnPb/SAC	60	60	60	60	60	12			
153	SnPb/SAC	60	60	60	60	60	43			
180	SnPb/SAC	60	60	60	60	60	55			
49	SnPb/SnPb	60	60	60	60	60	13			
46	SnPb/SnPb	60	60	60	60	60	60	7		
50	SnPb/SnPb	60	60	60	60	60	60	26		
43	SnPb/SnPb	60	60	60	60	60	60	60	10	
47	SnPb/SnPb	60	60	60	60	60	60	60	42	

Table D-9. BGA-225 U55 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/SAC	60	60	21						
155	SnPb/SAC	60	60	55						
156	SnPb/SAC	60	60	59						
157	SnPb/SAC	60	60	60	5					
153	SnPb/SAC	60	60	60	6					
182	SnPb/SAC	60	60	60	28					
183	SnPb/SAC	60	60	60	37					
184	SnPb/SAC	60	60	60	60	1				
154	SnPb/SAC	60	60	60	60	11				
185	SnPb/SAC	60	60	60	60	26				
46	SnPb/SnPb	60	60	60	52					
49	SnPb/SnPb	60	60	60	52					
50	SnPb/SnPb	60	60	60	60	27				
47	SnPb/SnPb	60	60	60	60	60	46			
43	SnPb/SnPb	60	60	60	60	60	57			

Table D-10. BGA-225 U56 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/SAC	60	60	60	53					
182	SnPb/SAC	60	60	60	60	60	16			
153	SnPb/SAC	60	60	60	60	60	60	3		
157	SnPb/SAC	60	60	60	60	60	60	31		
185	SnPb/SAC	60	60	60	60	60	60	44		
155	SnPb/SAC	60	60	60	60	60	60	60	6	
156	SnPb/SAC	60	60	60	60	60	60	60	7	
184	SnPb/SAC	60	60	60	60	60	60	60	59	
154	SnPb/SAC	60	60	60	60	60	60	60	60	4
183	SnPb/SAC	60	60	60	60	60	60	60	60	25
49	SnPb/SnPb	60	60	60	60	60	60	12		
47	SnPb/SnPb	60	60	60	60	60	60	60	60	33
50	SnPb/SnPb	60	60	60	60	60	60	60	60	58
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-11. CLCC-20 U9 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
157	SnPb/SAC	60	60	60	60	60	60	60	60	17
153	SnPb/SAC	60	60	60	60	60	60	60	60	28
154	SnPb/SAC	60	60	60	60	60	60	60	60	60
155	SnPb/SAC	60	60	60	60	60	60	60	60	60
156	SnPb/SAC	60	60	60	60	60	60	60	60	60
180	SnPb/SACB	60	60	60	60	60	60	60	60	32
184	SnPb/SACB	60	60	60	60	60	60	60	60	33
182	SnPb/SACB	60	60	60	60	60	60	60	60	60
183	SnPb/SACB	60	60	60	60	60	60	60	60	60
185	SnPb/SACB	60	60	60	60	60	60	60	60	60
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-12. CLCC-20 U10 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
155	SnPb/SAC	60	60	60	60	60	60	60	60	33	
153	SnPb/SAC	60	60	60	60	60	60	60	60	34	
154	SnPb/SAC	60	60	60	60	60	60	60	60	60	
156	SnPb/SAC	60	60	60	60	60	60	60	60	60	
157	SnPb/SAC	60	60	60	60	60	60	60	60	60	
180	SnPb/SACB	60	60	60	60	60	60	60	60	60	
182	SnPb/SACB	60	60	60	60	60	60	60	60	60	
183	SnPb/SACB	60	60	60	60	60	60	60	60	60	
184	SnPb/SACB	60	60	60	60	60	60	60	60	60	
185	SnPb/SACB	60	60	60	60	60	60	60	60	60	
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60	

Table D-13. CLCC-20 U13 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
157	SnPb/SAC	60	60	60	3					
155	SnPb/SAC	60	60	60	13					
154	SnPb/SAC	60	60	60	17					
156	SnPb/SAC	60	60	60	19					
153	SnPb/SAC	60	60	60	40					
180	SnPb/SACB	60	60	60	6					
185	SnPb/SACB	60	60	60	17					
182	SnPb/SACB	60	60	60	37					
184	SnPb/SACB	60	60	60	44					
183	SnPb/SACB	60	60	60	60	6				
47	SnPb/SnPb	60	60	60	19					
46	SnPb/SnPb	60	60	60	56					
43	SnPb/SnPb	60	60	60	58					
50	SnPb/SnPb	60	60	60	60	35				
49	SnPb/SnPb	60	60	60	60	60	11			

Table D-14. CLCC-20 U14 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SAC	60	60	49						
157	SnPb/SAC	60	60	60	3					
154	SnPb/SAC	60	60	60	7					
156	SnPb/SAC	60	60	60	10					
155	SnPb/SAC	60	60	60	18					
180	SnPb/SACB	60	60	37						
184	SnPb/SACB	60	60	37						
185	SnPb/SACB	60	60	60	6					
182	SnPb/SACB	60	60	60	34					
183	SnPb/SACB	60	60	60	42					
49	SnPb/SnPb	60	60	49						
47	SnPb/SnPb	60	60	59						
46	SnPb/SnPb	60	60	60	3					
50	SnPb/SnPb	60	60	60	36					
43	SnPb/SnPb	60	60	60	50					

Table D-15. CLCC-20 U17 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SAC	60	60	60	60	60	60	60	16	
155	SnPb/SAC	60	60	60	60	60	60	60	60	41
154	SnPb/SAC	60	60	60	60	60	60	60	60	60
156	SnPb/SAC	60	60	60	60	60	60	60	60	60
157	SnPb/SAC	60	60	60	60	60	60	60	60	60
184	SnPb/SACB	60	60	60	60	60	60	60	60	1
180	SnPb/SACB	60	60	60	60	60	60	60	60	60
182	SnPb/SACB	60	60	60	60	60	60	60	60	60
183	SnPb/SACB	60	60	60	60	60	60	60	60	60
185	SnPb/SACB	60	60	60	60	60	60	60	60	60
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-16. CLCC-20 U22 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms	
153	SnPb/SAC	60	60	60	60	60	60	60	60	60	34
154	SnPb/SAC	60	60	60	60	60	60	60	60	60	37
155	SnPb/SAC	60	60	60	60	60	60	60	60	60	47
156	SnPb/SAC	60	60	60	60	60	60	60	60	60	60
157	SnPb/SAC	60	60	60	60	60	60	60	60	60	60
180	SnPb/SACB	60	60	60	60	36					
182	SnPb/SACB	60	60	60	60	60	60	60	60	60	60
183	SnPb/SACB	60	60	60	60	60	60	60	60	60	60
184	SnPb/SACB	60	60	60	60	60	60	60	60	60	60
185	SnPb/SACB	60	60	60	60	60	60	60	60	60	60
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60	60

Table D-17. CLCC-20 U45 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SAC	60	60	60	60	60	60	60	60	60
154	SnPb/SAC	60	60	60	60	60	60	60	60	60
155	SnPb/SAC	60	60	60	60	60	60	60	60	60
156	SnPb/SAC	60	60	60	60	60	60	60	60	60
157	SnPb/SAC	60	60	60	60	60	60	60	60	60
180	SnPb/SACB	60	60	60	60	60	60	60	60	60
182	SnPb/SACB	60	60	60	60	60	60	60	60	60
183	SnPb/SACB	60	60	60	60	60	60	60	60	60
184	SnPb/SACB	60	60	60	60	60	60	60	60	60
185	SnPb/SACB	60	60	60	60	60	60	60	60	60
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-18. CLCC-20 U46 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SAC	60	60	60	60	60	60	60	60	15
157	SnPb/SAC	60	60	60	60	60	60	60	60	35
156	SnPb/SAC	60	60	60	60	60	60	60	60	51
154	SnPb/SAC	60	60	60	60	60	60	60	60	53
155	SnPb/SAC	60	60	60	60	60	60	60	60	60
180	SnPb/SACB	60	60	60	60	60	60	60	60	4
182	SnPb/SACB	60	60	60	60	60	60	60	60	60
183	SnPb/SACB	60	60	60	60	60	60	60	60	60
184	SnPb/SACB	60	60	60	60	60	60	60	60	60
185	SnPb/SACB	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	2
43	SnPb/SnPb	60	60	60	60	60	60	60	60	17
49	SnPb/SnPb	60	60	60	60	60	60	60	60	21
50	SnPb/SnPb	60	60	60	60	60	60	60	60	40
46	SnPb/SnPb	60	60	60	60	60	60	60	60	43

Table D-19. CLCC-20 U52 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms	
156	SnPb/SAC	60	60	60	60	60	60	44			
154	SnPb/SAC	60	60	60	60	60	60	60	3		
155	SnPb/SAC	60	60	60	60	60	60	60	55		
157	SnPb/SAC	60	60	60	60	60	60	60	60	6	
153	SnPb/SAC	60	60	60	60	60	60	60	60	17	
180	SnPb/SACB	60	60	60	60	36					
182	SnPb/SACB	60	60	60	60	60	60	57			
183	SnPb/SACB	60	60	60	60	60	60	60	29		
185	SnPb/SACB	60	60	60	60	60	60	60	60	3	
184	SnPb/SACB	60	60	60	60	60	60	60	60	24	
49	SnPb/SnPb	60	60	60	60	60	60	50			
47	SnPb/SnPb	60	60	60	60	60	60	60	60	11	
46	SnPb/SnPb	60	60	60	60	60	60	60	60	35	
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60	

Table D-20. CLCC-20 U53 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
154	SnPb/SAC	60	60	60	60	60	60	58			
157	SnPb/SAC	60	60	60	60	60	60	60	59		
153	SnPb/SAC	60	60	60	60	60	60	60	60	3	
155	SnPb/SAC	60	60	60	60	60	60	60	60	13	
156	SnPb/SAC	60	60	60	60	60	60	60	60	33	
180	SnPb/SACB	60	60	60	60	60	60	60	60	4	
183	SnPb/SACB	60	60	60	60	60	60	60	60	18	
182	SnPb/SACB	60	60	60	60	60	60	60	60	29	
185	SnPb/SACB	60	60	60	60	60	60	60	60	44	
184	SnPb/SACB	60	60	60	60	60	60	60	60	58	
49	SnPb/SnPb	60	60	60	60	60	60	60	60	7	
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60	
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60	

Table D-21. PDIP-20 U23 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SAC/NiPdAu	60	60	60	38					
155	SAC/NiPdAu	60	60	60	53					
156	SAC/NiPdAu	60	60	60	60	7				
157	SAC/NiPdAu	60	60	60	60	32				
154	SAC/NiPdAu	60	60	60	60	60	60	13		
185	SnCu/NiPdAu	60	60	60	10					
182	SnCu/NiPdAu	60	60	60	29					
180	SnCu/NiPdAu	60	60	60	60	60	60	60	60	
183	SnCu/NiPdAu	60	60	60	60	60	60	60	60	
184	SnCu/NiPdAu	60	60	60	60	60	60	60	60	
49	SnPb/NiPdAu	60	60	44						
46	SnPb/NiPdAu	60	60	60	60	60	60	60	60	
47	SnPb/NiPdAu	60	60	60	60	60	60	60	60	
43	SnPb/NiPdAu	60	60	60	60	60	60	60	60	
50	SnPb/NiPdAu	60	60	60	60	60	60	60	60	

This part was reworked.

Table D-22. PDIP-20 U59 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SAC/NiPdAu	60	60	14						
155	SAC/NiPdAu	60	60	25						
157	SAC/NiPdAu	60	60	28						
156	SAC/NiPdAu	60	60	60	60	22				
154	SAC/NiPdAu	60	60	60	60	49				
182	SnCu/NiPdAu	60	60	45						
185	SnCu/NiPdAu	60	60	58						
183	SnCu/NiPdAu	60	60	60	16					
180	SnCu/NiPdAu	60	60	60	60	36				
184	SnCu/NiPdAu	60	60	60	60	60	60	60	60	60
49	SnPb/NiPdAu	60	60	60	60	60	39			
46	SnPb/NiPdAu	60	60	60	60	60	60	60	60	1
50	SnPb/NiPdAu	60	60	60	60	60	60	60	60	30
47	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60
43	SnPb/NiPdAu	60	60	60	60	60	60	60	60	60

This part was reworked.

Table D-23. PDIP-20 U8 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
185	SnPb/NiPdAu	bad part								
155	SnPb/NiPdAu	60	60	11						
156	SnPb/NiPdAu	60	60	16						
180	SnPb/NiPdAu	60	60	25						
183	SnPb/NiPdAu	60	60	30						
153	SnPb/NiPdAu	60	60	32						
47	SnPb/NiPdAu	60	60	34						
157	SnPb/NiPdAu	60	60	46						
50	SnPb/NiPdAu	60	60	50						
184	SnPb/NiPdAu	60	60	59						
46	SnPb/NiPdAu	60	60	60	2					
182	SnPb/NiPdAu	60	60	60	15					
43	SnPb/NiPdAu	60	60	60	17					
49	SnPb/NiPdAu	60	60	60	33					
154	SnPb/NiPdAu	60	60	60	45					

Table D-24. PDIP-20 U35 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
49	SnPb/NiPdAu	60	60	37						
183	SnPb/NiPdAu	60	60	40						
184	SnPb/NiPdAu	60	60	60	2					
50	SnPb/NiPdAu	60	60	60	5					
180	SnPb/NiPdAu	60	60	60	8					
157	SnPb/NiPdAu	60	60	60	13					
153	SnPb/NiPdAu	60	60	60	21					
156	SnPb/NiPdAu	60	60	60	38					
155	SnPb/NiPdAu	60	60	60	44					
43	SnPb/NiPdAu	60	60	60	60	10				
46	SnPb/NiPdAu	60	60	60	60	14				
47	SnPb/NiPdAu	60	60	60	60	21				
185	SnPb/NiPdAu	60	60	60	60	38				
182	SnPb/NiPdAu	60	60	60	60	57				
154	SnPb/NiPdAu	60	60	60	60	60	22			

Table D-25. PDIP-20 U49 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
50	SnPb/NiPdAu	bad part								
49	SnPb/NiPdAu	60	60	21						
184	SnPb/NiPdAu	60	60	40						
43	SnPb/NiPdAu	60	60	55						
157	SnPb/NiPdAu	60	60	60	1					
153	SnPb/NiPdAu	60	60	60	18					
154	SnPb/NiPdAu	60	60	60	24					
155	SnPb/NiPdAu	60	60	60	28					
180	SnPb/NiPdAu	60	60	60	28					
47	SnPb/NiPdAu	60	60	60	35					
182	SnPb/NiPdAu	60	60	60	42					
183	SnPb/NiPdAu	60	60	60	60	28				
46	SnPb/NiPdAu	60	60	60	60	45				
185	SnPb/NiPdAu	60	60	60	60	60	8			
156	SnPb/NiPdAu	60	60	60	60	60	60	60	9	

Table D-26. PDIP-20 U11 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
185	SnPb/Sn	60	60	55						
182	SnPb/Sn	60	60	58						
153	SnPb/Sn	60	60	60	3					
155	SnPb/Sn	60	60	60	5					
156	SnPb/Sn	60	60	60	6					
50	SnPb/Sn	60	60	60	16					
180	SnPb/Sn	60	60	60	32					
154	SnPb/Sn	60	60	60	44					
184	SnPb/Sn	60	60	60	60	18				
49	SnPb/Sn	60	60	60	60	27				
183	SnPb/Sn	60	60	60	60	36				
157	SnPb/Sn	60	60	60	60	37				
46	SnPb/Sn	60	60	60	60	38				
47	SnPb/Sn	60	60	60	60	60	15			
43	SnPb/Sn	60	60	60	60	60	60	14		

Table D-27. PDIP-20 U30 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/Sn	60	60	14						
157	SnPb/Sn	60	60	60	60					
47	SnPb/Sn	60	60	60	60	10				
184	SnPb/Sn	60	60	60	60	12				
180	SnPb/Sn	60	60	60	60	36				
46	SnPb/Sn	60	60	60	60	60	20			
155	SnPb/Sn	60	60	60	60	60	33			
182	SnPb/Sn	60	60	60	60	60	60	11		
50	SnPb/Sn	60	60	60	60	60	60	12		
43	SnPb/Sn	60	60	60	60	60	60	30		
154	SnPb/Sn	60	60	60	60	60	60	32		
156	SnPb/Sn	60	60	60	60	60	60	43		
49	SnPb/Sn	60	60	60	60	60	60	46		
185	SnPb/Sn	60	60	60	60	60	60	56		
183	SnPb/Sn	60	60	60	60	60	60	60	15	

Table D-28. PDIP-20 U38 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
46	SnPb/Sn	60	60	34						
180	SnPb/Sn	60	60	43						
43	SnPb/Sn	60	60	60	3					
50	SnPb/Sn	60	60	60	20					
47	SnPb/Sn	60	60	60	25					
184	SnPb/Sn	60	60	60	60	2				
157	SnPb/Sn	60	60	60	60	17				
183	SnPb/Sn	60	60	60	60	25				
153	SnPb/Sn	60	60	60	60	57				
182	SnPb/Sn	60	60	60	60	60	15			
49	SnPb/Sn	60	60	60	60	60	19			
154	SnPb/Sn	60	60	60	60	60	38			
156	SnPb/Sn	60	60	60	60	60	46			
155	SnPb/Sn	60	60	60	60	60	52			
185	SnPb/Sn	60	60	60	60	60	60	60	60	38

Table D-29. PDIP-20 U51 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/Sn	60	60	43						
156	SnPb/Sn	60	60	60	6					
153	SnPb/Sn	60	60	60	19					
157	SnPb/Sn	60	60	60	22					
184	SnPb/Sn	60	60	60	28					
50	SnPb/Sn	60	60	60	30					
183	SnPb/Sn	60	60	60	60	6				
155	SnPb/Sn	60	60	60	60	11				
46	SnPb/Sn	60	60	60	60	13				
185	SnPb/Sn	60	60	60	60	15				
49	SnPb/Sn	60	60	60	60	42				
154	SnPb/Sn	60	60	60	60	60	60	14		
182	SnPb/Sn	60	60	60	60	60	60	25		
43	SnPb/Sn	60	60	60	60	60	60	37		
47	SnPb/Sn	60	60	60	60	60	60	60	60	47

Table D-30. PDIP-20 U63 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
156	SnPb/Sn	60	60	31						
180	SnPb/Sn	60	60	31						
49	SnPb/Sn	60	60	37						
155	SnPb/Sn	60	60	47						
183	SnPb/Sn	60	60	47						
157	SnPb/Sn	60	60	56						
185	SnPb/Sn	60	60	59						
182	SnPb/Sn	60	60	60	5					
154	SnPb/Sn	60	60	60	12					
153	SnPb/Sn	60	60	60	28					
184	SnPb/Sn	60	60	60	48					
47	SnPb/Sn	60	60	60	56					
50	SnPb/Sn	60	60	60	60	1				
46	SnPb/Sn	60	60	60	60	3				
43	SnPb/Sn	60	60	60	60	6				

Table D-31. TSOP-50 U12 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
156	SAC/SnCu	60	60	60							
155	SAC/SnCu	60	60	60	33						
154	SAC/SnCu	60	60	60	60	5					
157	SAC/SnCu	60	60	60	60	6					
153	SAC/SnCu	60	60	60	60	12					
184	SACB/SnCu	60	60	21							
183	SACB/SnCu	60	60	58							
180	SACB/SnCu	60	60	60	3						
182	SACB/SnCu	60	60	60	43						
185	SACB/SnCu	60	60	60	60	4					
47	SnPb/SnPb	60	60	9							
49	SnPb/SnPb	60	60	60	23						
50	SnPb/SnPb	60	60	60	60	35					
46	SnPb/SnPb	60	60	60	60	60	7				
43	SnPb/SnPb	60	60	60	60	60	60	60	60	4	

This part was reworked.

Table D-32. TSOP-50 U25 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
154	SAC/SnCu	60	60	60	4						
155	SAC/SnCu	60	60	60	23						
153	SAC/SnCu	60	60	60	51						
156	SAC/SnCu	60	60	60	54						
157	SAC/SnCu	60	60	60	60	4					
180	SACB/SnCu	60	60	27							
185	SACB/SnCu	60	60	60							
184	SACB/SnCu	60	60	60	17						
183	SACB/SnCu	60	60	60	22						
182	SACB/SnCu	60	60	60	46						
47	SnPb/SnPb	bad part									
50	SnPb/SnPb	60	60	11							
46	SnPb/SnPb	60	60	35							
43	SnPb/SnPb	60	60	50							
49	SnPb/SnPb	60	60	60	13						

This part was reworked.

Table D-33. TSOP-50 U16 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SnCu	60	60	60	60	60	21			
184	SnPb/SnCu	60	60	60	60	60	38			
156	SnPb/SnCu	60	60	60	60	60	39			
180	SnPb/SnCu	60	60	60	60	60	60	7		
155	SnPb/SnCu	60	60	60	60	60	60	14		
157	SnPb/SnCu	60	60	60	60	60	60	60	23	
185	SnPb/SnCu	60	60	60	60	60	60	60	60	19
182	SnPb/SnCu	60	60	60	60	60	60	60	60	45
154	SnPb/SnCu	60	60	60	60	60	60	60	60	60
183	SnPb/SnCu	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	13		
47	SnPb/SnPb	60	60	60	60	60	60	55		
43	SnPb/SnPb	60	60	60	60	60	60	60	11	
46	SnPb/SnPb	60	60	60	60	60	60	60	60	32
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-34. TSOP-50 U24 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
153	SnPb/SnCu	60	60	60	17						
155	SnPb/SnCu	60	60	60	17						
184	SnPb/SnCu	60	60	60	32						
180	SnPb/SnCu	60	60	60	60						
157	SnPb/SnCu	60	60	60	60	2					
183	SnPb/SnCu	60	60	60	60	2					
156	SnPb/SnCu	60	60	60	60	8					
185	SnPb/SnCu	60	60	60	60	11					
154	SnPb/SnCu	60	60	60	60	13					
182	SnPb/SnCu	60	60	60	60	38					
43	SnPb/SnPb	60	60	60	38						
46	SnPb/SnPb	60	60	60	48						
50	SnPb/SnPb	60	60	60	51						
47	SnPb/SnPb	60	60	60	60	6					
49	SnPb/SnPb	60	60	60	60	28					

Table D-35. TSOP-50 U26 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/SnCu	60	60	60	60	21				
153	SnPb/SnCu	60	60	60	60	54				
156	SnPb/SnCu	60	60	60	60	60	9			
182	SnPb/SnCu	60	60	60	60	60	12			
183	SnPb/SnCu	60	60	60	60	60	12			
155	SnPb/SnCu	60	60	60	60	60	40			
157	SnPb/SnCu	60	60	60	60	60	41			
184	SnPb/SnCu	60	60	60	60	60	60	17		
154	SnPb/SnCu	60	60	60	60	60	60	46		
185	SnPb/SnCu	60	60	60	60	60	60	60	60	37
49	SnPb/SnPb	60	60	60	60	60	60	6		
46	SnPb/SnPb	60	60	60	60	60	60	60	19	
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-36. TSOP-50 U29 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SnCu	60	60	60	60	60	50			
184	SnPb/SnCu	60	60	60	60	60	57			
157	SnPb/SnCu	60	60	60	60	60	60	13		
156	SnPb/SnCu	60	60	60	60	60	60	15		
155	SnPb/SnCu	60	60	60	60	60	60	55		
180	SnPb/SnCu	60	60	60	60	60	60	60	20	
182	SnPb/SnCu	60	60	60	60	60	60	60	60	11
183	SnPb/SnCu	60	60	60	60	60	60	60	60	18
154	SnPb/SnCu	60	60	60	60	60	60	60	60	60
185	SnPb/SnCu	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	53		
50	SnPb/SnPb	60	60	60	60	60	60	60	60	9
46	SnPb/SnPb	60	60	60	60	60	60	60	60	26
43	SnPb/SnPb	60	60	60	60	60	60	60	60	28
49	SnPb/SnPb	60	60	60	60	60	60	60	60	42

Table D-37. TSOP-50 U39 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/SnCu	60	60	60	60	60	60	60	60	45
157	SnPb/SnCu	60	60	60	60	60	60	60	60	57
182	SnPb/SnCu	60	60	60	60	60	60	60	60	58
183	SnPb/SnCu	60	60	60	60	60	60	60	60	60
154	SnPb/SnCu	60	60	60	60	60	60	60	60	60
155	SnPb/SnCu	60	60	60	60	60	60	60	60	60
156	SnPb/SnCu	60	60	60	60	60	60	60	60	60
180	SnPb/SnCu	60	60	60	60	60	60	60	60	60
184	SnPb/SnCu	60	60	60	60	60	60	60	60	60
185	SnPb/SnCu	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	50
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-38. TSOP-50 U40 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
157	SnPb/SnCu	60	60	60	60	60	60	13		
153	SnPb/SnCu	60	60	60	60	60	60	55		
155	SnPb/SnCu	60	60	60	60	60	60	60	1	
183	SnPb/SnCu	60	60	60	60	60	60	60	3	
180	SnPb/SnCu	60	60	60	60	60	60	60	29	
182	SnPb/SnCu	60	60	60	60	60	60	60	38	
156	SnPb/SnCu	60	60	60	60	60	60	60	41	
154	SnPb/SnCu	60	60	60	60	60	60	60	60	7
184	SnPb/SnCu	60	60	60	60	60	60	60	60	12
185	SnPb/SnCu	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	44		
43	SnPb/SnPb	60	60	60	60	60	60	49		
50	SnPb/SnPb	60	60	60	60	60	60	60	5	
46	SnPb/SnPb	60	60	60	60	60	60	60	33	
47	SnPb/SnPb	60	60	60	60	60	60	60	46	

Table D-39. TSOP-50 U61 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
155	SnPb/SnCu	60	60	60	60	60	60	16		
182	SnPb/SnCu	60	60	60	60	60	60	25		
157	SnPb/SnCu	60	60	60	60	60	60	54		
153	SnPb/SnCu	60	60	60	60	60	60	60	14	
154	SnPb/SnCu	60	60	60	60	60	60	60	14	
183	SnPb/SnCu	60	60	60	60	60	60	60	20	
156	SnPb/SnCu	60	60	60	60	60	60	60	23	
184	SnPb/SnCu	60	60	60	60	60	60	60	60	12
180	SnPb/SnCu	60	60	60	60	60	60	60	60	13
185	SnPb/SnCu	60	60	60	60	60	60	60	60	54
49	SnPb/SnPb	60	60	60	60	60	60	60	7	
46	SnPb/SnPb	60	60	60	60	60	60	60	60	1
50	SnPb/SnPb	60	60	60	60	60	60	60	60	46
47	SnPb/SnPb	60	60	60	60	60	60	60	60	
43	SnPb/SnPb	60	60	60	60	60	60	60	60	

Table D-40. TSOP-50 U62 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
183	SnPb/SnCu	60	60	60	60	60	60	60	60	3
155	SnPb/SnCu	60	60	60	60	60	60	60	60	4
157	SnPb/SnCu	60	60	60	60	60	60	60	60	8
154	SnPb/SnCu	60	60	60	60	60	60	60	60	29
182	SnPb/SnCu	60	60	60	60	60	60	60	60	37
156	SnPb/SnCu	60	60	60	60	60	60	60	60	46
153	SnPb/SnCu	60	60	60	60	60	60	60	60	60
180	SnPb/SnCu	60	60	60	60	60	60	60	60	60
184	SnPb/SnCu	60	60	60	60	60	60	60	60	60
185	SnPb/SnCu	60	60	60	60	60	60	60	60	60
49	SnPb/SnPb	60	60	60	60	60	60	60	60	35
46	SnPb/SnPb	60	60	60	60	60	60	60	60	60
47	SnPb/SnPb	60	60	60	60	60	60	60	60	60
43	SnPb/SnPb	60	60	60	60	60	60	60	60	60
50	SnPb/SnPb	60	60	60	60	60	60	60	60	60

Table D-41. PLCC-20 U15 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
180	SnPb/Sn	bad part								
183	SnPb/Sn	60	60	60	8					
46	SnPb/Sn	60	60	60	26					
153	SnPb/Sn	60	60	60	60	1				
47	SnPb/Sn	60	60	60	60	1				
49	SnPb/Sn	60	60	60	60	20				
50	SnPb/Sn	60	60	60	60	40				
184	SnPb/Sn	60	60	60	60	43				
154	SnPb/Sn	60	60	60	60	54				
155	SnPb/Sn	60	60	60	60	60	15			
182	SnPb/Sn	60	60	60	60	60	17			
156	SnPb/Sn	60	60	60	60	60	60	9		
157	SnPb/Sn	60	60	60	60	60	60	37		
43	SnPb/Sn	60	60	60	60	60	60	60	23	
185	SnPb/Sn	60	60	60	60	60	60	60	60	5

Table D-42. PLCC-20 U27 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/Sn	60	60	60	60	60	60	60	60	60
154	SnPb/Sn	60	60	60	60	60	60	60	60	60
155	SnPb/Sn	60	60	60	60	60	60	60	60	60
156	SnPb/Sn	60	60	60	60	60	60	60	60	60
157	SnPb/Sn	60	60	60	60	60	60	60	60	60
180	SnPb/Sn	60	60	60	60	60	60	60	60	60
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
183	SnPb/Sn	60	60	60	60	60	60	60	60	60
184	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
46	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60
49	SnPb/Sn	60	60	60	60	60	60	60	60	60
50	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table D-43. PLCC-20 U28 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
153	SnPb/Sn	60	60	60	60	60	60	60	60	60
154	SnPb/Sn	60	60	60	60	60	60	60	60	60
155	SnPb/Sn	60	60	60	60	60	60	60	60	60
156	SnPb/Sn	60	60	60	60	60	60	60	60	60
157	SnPb/Sn	60	60	60	60	60	60	60	60	60
180	SnPb/Sn	60	60	60	60	60	60	60	60	60
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
183	SnPb/Sn	60	60	60	60	60	60	60	60	60
184	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
46	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60
49	SnPb/Sn	60	60	60	60	60	60	60	60	60
50	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table D-44. PLCC-20 U47 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
49	SnPb/Sn	60	60	60	60	60	60	60	60	50
153	SnPb/Sn	60	60	60	60	60	60	60	60	60
154	SnPb/Sn	60	60	60	60	60	60	60	60	60
155	SnPb/Sn	60	60	60	60	60	60	60	60	60
156	SnPb/Sn	60	60	60	60	60	60	60	60	60
157	SnPb/Sn	60	60	60	60	60	60	60	60	60
180	SnPb/Sn	60	60	60	60	60	60	60	60	60
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
183	SnPb/Sn	60	60	60	60	60	60	60	60	60
184	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
46	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60
50	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table D-45. PLCC-20 U54 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SnPb/Sn	60	60	60	60	60	60	60	60	60
154	SnPb/Sn	60	60	60	60	60	60	60	60	60
155	SnPb/Sn	60	60	60	60	60	60	60	60	60
156	SnPb/Sn	60	60	60	60	60	60	60	60	60
157	SnPb/Sn	60	60	60	60	60	60	60	60	60
180	SnPb/Sn	60	60	60	60	60	60	60	60	60
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
183	SnPb/Sn	60	60	60	60	60	60	60	60	60
184	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
46	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60
49	SnPb/Sn	60	60	60	60	60	60	60	60	60
50	SnPb/Sn	60	60	60	60	60	60	60	60	60

Table D-46. TQFP-144 U1 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
156	SnPb/Sn	60	60	60	60	60	60	40*		
155	SnPb/Sn	60	60	60	60	60	60	60	32*	
184	SnPb/Sn	60	60	60	60	60	60	60	60	2
49	SnPb/Sn	60	60	60	60	60	60	60	60	4
153	SnPb/Sn	60	60	60	60	60	60	60	60	9
154	SnPb/Sn	60	60	60	60	60	60	60	60	25
180	SnPb/Sn	60	60	60	60	60	60	60	60	29
157	SnPb/Sn	60	60	60	60	60	60	60	60	33*
46	SnPb/Sn	60	60	60	60	60	60	60	60	34
183	SnPb/Sn	60	60	60	60	60	60	60	60	41
50	SnPb/Sn	60	60	60	60	60	60	60	60	59
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60

*Broken or cracked leads.

Table D-47. TQFP-144 U7 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
156	SnPb/Sn	60	60	60	60	60	60	60	60	6
155	SnPb/Sn	60	60	60	60	60	60	60	60	8*
184	SnPb/Sn	60	60	60	60	60	60	60	60	8*
47	SnPb/Sn	60	60	60	60	60	60	60	60	15
46	SnPb/Sn	60	60	60	60	60	60	60	60	20
153	SnPb/Sn	60	60	60	60	60	60	60	60	30
43	SnPb/Sn	60	60	60	60	60	60	60	60	32
50	SnPb/Sn	60	60	60	60	60	60	60	60	32*
180	SnPb/Sn	60	60	60	60	60	60	60	60	40
154	SnPb/Sn	60	60	60	60	60	60	60	60	45
157	SnPb/Sn	60	60	60	60	60	60	60	60	60
182	SnPb/Sn	60	60	60	60	60	60	60	60	60
183	SnPb/Sn	60	60	60	60	60	60	60	60	60
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
49	SnPb/Sn	60	60	60	60	60	60	60	60	60

***Broken or cracked leads.**

Table D-48. TQFP-144 U20 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
155	SnPb/Sn	60	60	60	21*					
154	SnPb/Sn	60	60	60	50*					
184	SnPb/Sn	60	60	60	60	15*				
50	SnPb/Sn	60	60	60	60	20*				
47	SnPb/Sn	60	60	60	60	26*				
46	SnPb/Sn	60	60	60	60	41*				
156	SnPb/Sn	60	60	60	60	59*				
180	SnPb/Sn	60	60	60	60	60	17*			
157	SnPb/Sn	60	60	60	60	60	19*			
49	SnPb/Sn	60	60	60	60	60	25*			
183	SnPb/Sn	60	60	60	60	60	31*			
185	SnPb/Sn	60	60	60	60	60	37*			
182	SnPb/Sn	60	60	60	60	60	45			
153	SnPb/Sn	60	60	60	60	60	60	10*		
43	SnPb/Sn	60	60	60	60	60	60	58		

*Broken or cracked leads.

Table D-49. TQFP-144 U41 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
155	SnPb/Sn	60	60	60	60	60	18*			
182	SnPb/Sn	60	60	60	60	60	54*			
157	SnPb/Sn	60	60	60	60	60	57*			
180	SnPb/Sn	60	60	60	60	60	60	2*		
156	SnPb/Sn	60	60	60	60	60	60	13*		
154	SnPb/Sn	60	60	60	60	60	60	19*		
46	SnPb/Sn	60	60	60	60	60	60	57*		
183	SnPb/Sn	60	60	60	60	60	60	59*		
153	SnPb/Sn	60	60	60	60	60	60	60	9*	
49	SnPb/Sn	60	60	60	60	60	60	60	11	
50	SnPb/Sn	60	60	60	60	60	60	60	60	11*
184	SnPb/Sn	60	60	60	60	60	60	60	60	17*
185	SnPb/Sn	60	60	60	60	60	60	60	60	60
47	SnPb/Sn	60	60	60	60	60	60	60	60	60
43	SnPb/Sn	60	60	60	60	60	60	60	60	60

*Broken or cracked leads.

Table D-50. TQFP-144 U58 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
154	SnPb/Sn	60	60	60	12*					
183	SnPb/Sn	60	60	60	24*					
184	SnPb/Sn	60	60	60	25*					
180	SnPb/Sn	60	60	60	32*					
155	SnPb/Sn	60	60	60	36*					
49	SnPb/Sn	60	60	60	37*					
50	SnPb/Sn	60	60	60	37*					
157	SnPb/Sn	60	60	60	46*					
47	SnPb/Sn	60	60	60	57*					
182	SnPb/Sn	60	60	60	60	5*				
156	SnPb/Sn	60	60	60	60	12*				
46	SnPb/Sn	60	60	60	60	15*				
153	SnPb/Sn	60	60	60	60	16*				
185	SnPb/Sn	60	60	60	60	30*				
43	SnPb/Sn	60	60	60	60	34*				

***Broken or cracked leads.**

Table D-51. TQFP-208 U3 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
153	SAC/NiPdAu	bad part								
157	SAC/NiPdAu	bad part								
156	SAC/NiPdAu	60	60	7*						
155	SAC/NiPdAu	60	60	23*						
154	SAC/NiPdAu	60	60	30*						
182	SACB/NiPdAu	bad part								
183	SACB/NiPdAu	bad part								
184	SACB/NiPdAu	bad part								
185	SACB/NiPdAu	bad part								
180	SACB/NiPdAu	60	60	2*						
43	SnPb/NiPdAu	bad part								
50	SnPb/NiPdAu	60	60	25*						
46	SnPb/NiPdAu	60	60	27*						
47	SnPb/NiPdAu	60	60	29*						
49	SnPb/NiPdAu	60	60	60*						

This part was reworked.

***Broken or cracked leads.**

Table D-52. TQFP-208 U57 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)									
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms	
154	SAC/NiPdAu	60	60	60*							
153	SAC/NiPdAu	60	60	60	13*						
155	SAC/NiPdAu	60	60	60	13*						
157	SAC/NiPdAu	60	60	60	17*						
156	SAC/NiPdAu	60	60	60	19*						
180	SACB/NiPdAu	60	60	53*							
183	SACB/NiPdAu	60	60	60	13*						
182	SACB/NiPdAu	60	60	60	21*						
184	SACB/NiPdAu	60	60	60	31*						
185	SACB/NiPdAu	60	60	60	35*						
49	SnPb/NiPdAu	bad part									
43	SnPb/NiPdAu	60	60	15*							
50	SnPb/NiPdAu	60	60	56*							
47	SnPb/NiPdAu	60	60	60	2*						
46	SnPb/NiPdAu	60	60	60	37*						

This part was reworked.

***Broken or cracked leads.**

Table D-53. TQFP-208 U31 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
47	SnPb/NiPdAu	60	60	60	60	60	40			
50	SnPb/NiPdAu	60	60	60	60	60	60	12*		
184	SnPb/NiPdAu	60	60	60	60	60	60	29*		
43	SnPb/NiPdAu	60	60	60	60	60	60	30		
157	SnPb/NiPdAu	60	60	60	60	60	60	57		
155	SnPb/NiPdAu	60	60	60	60	60	60	60	1	
153	SnPb/NiPdAu	60	60	60	60	60	60	60	3	
154	SnPb/NiPdAu	60	60	60	60	60	60	60	20	
180	SnPb/NiPdAu	60	60	60	60	60	60	60	29	
46	SnPb/NiPdAu	60	60	60	60	60	60	60	35*	
156	SnPb/NiPdAu	60	60	60	60	60	60	60	44*	
182	SnPb/NiPdAu	60	60	60	60	60	60	60	60	5*
49	SnPb/NiPdAu	60	60	60	60	60	60	60	60	7*
183	SnPb/NiPdAu	60	60	60	60	60	60	60	60	16
185	SnPb/NiPdAu	60	60	60	60	60	60	60	60	16

***Broken or cracked leads.**

Table D-54. TQFP-208 U34 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
46	SnPb/NiPdAu	bad part								
155	SnPb/NiPdAu	60	60	60	60	60	3*			
154	SnPb/NiPdAu	60	60	60	60	60	26*			
157	SnPb/NiPdAu	60	60	60	60	60	53*			
184	SnPb/NiPdAu	60	60	60	60	60	60	18*		
49	SnPb/NiPdAu	60	60	60	60	60	60	25*		
180	SnPb/NiPdAu	60	60	60	60	60	60	27		
153	SnPb/NiPdAu	60	60	60	60	60	60	35		
156	SnPb/NiPdAu	60	60	60	60	60	60	41*		
182	SnPb/NiPdAu	60	60	60	60	60	60	60	1*	
183	SnPb/NiPdAu	60	60	60	60	60	60	60	1*	
185	SnPb/NiPdAu	60	60	60	60	60	60	60	23	
50	SnPb/NiPdAu	60	60	60	60	60	60	60	26*	
47	SnPb/NiPdAu	60	60	60	60	60	60	60	47	
43	SnPb/NiPdAu	60	60	60	60	60	60	60	60	15

*Broken or cracked leads.

Table D-55. TQFP-208 U48 (“Rework” PWA’s)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis 9.9 Grms	X-axis 9.9 Grms	Z-axis 9.9 Grms	Z-axis 12.0 Grms	Z-axis 14.0 Grms	Z-axis 16.0 Grms	Z-axis 18.0 Grms	Z-axis 20.0 Grms	Z-axis 28.0 Grms
50	SnPb/NiPdAu	bad part								
154	SnPb/NiPdAu	60	60	60	60	60	60	36*		
180	SnPb/NiPdAu	60	60	60	60	60	60	60	10	
49	SnPb/NiPdAu	60	60	60	60	60	60	60	14*	
155	SnPb/NiPdAu	60	60	60	60	60	60	60	30	
183	SnPb/NiPdAu	60	60	60	60	60	60	60	31*	
157	SnPb/NiPdAu	60	60	60	60	60	60	60	33*	
46	SnPb/NiPdAu	60	60	60	60	60	60	60	48	
184	SnPb/NiPdAu	60	60	60	60	60	60	60	60	1
156	SnPb/NiPdAu	60	60	60	60	60	60	60	60	6*
182	SnPb/NiPdAu	60	60	60	60	60	60	60	60	9
153	SnPb/NiPdAu	60	60	60	60	60	60	60	60	12
185	SnPb/NiPdAu	60	60	60	60	60	60	60	60	12
47	SnPb/NiPdAu	60	60	60	60	60	60	60	60	29
43	SnPb/NiPdAu	60	60	60	60	60	60	60	60	32

***Broken or cracked leads.**

Table D-56. Plated Through Holes (“Rework” PWA’s, 16.0 mils as drilled)

Test Vehicle ID	Solder Fill	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
43	SnPb	60	60	60	60	60	60	60	60	60
46	SnPb	60	60	60	60	60	60	60	60	60
47	SnPb	60	60	60	60	60	60	60	60	60
49	SnPb	60	60	60	60	60	60	60	60	60
50	SnPb	60	60	60	60	60	60	60	60	60
153	SnPb	60	60	60	60	60	60	60	60	60
154	SnPb	60	60	60	60	60	60	60	60	60
155	SnPb	60	60	60	60	60	60	60	60	60
156	SnPb	60	60	60	60	60	60	60	60	60
157	SnPb	60	60	60	60	60	60	60	60	60
180	SnPb	60	60	60	60	60	60	60	60	60
182	SnPb	60	60	60	60	60	60	60	60	60
183	SnPb	60	60	60	60	60	60	60	60	60
184	SnPb	60	60	60	60	60	60	60	60	60
185	SnPb	60	60	60	60	60	60	60	60	60

Appendix E. Accelerometer Data (First Resonance Frequencies and Calculated Q Values)

Table E-1. Accelerometer Data (“Manufactured” PWA’s)

	First Resonance from 1G Sine Sweep (Hz)	Q (from 1G Sine Sweep)	First Resonance @ 9.9Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 12.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 14.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 16.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 18.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 20.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 28.0Grms (Hz)	(Response @ First Resonance/Input)*0.5
Board ID																
5	67.8	29	72.5	13.7	67.5	13.4	67.5	12.9	70	11.9	67.5	10.3	65	9.3	65	8.3
6			72.5	13.7	70	11.5	67.5	10.0	67.5	11.3	67.5	9.9	67.5	8.4	67.5	7.9
7	68.5	27	72.5	14.5	70	14.0	70	12.7	70	13.8	67.5	11.3	67.5	11.4	67.5	9.5
8	71.8	25	75	16.0	72.5	14.0	72.5	12.5	70	11.7	70	11.9	70	10.1	70	9.0
9			na	na	na	na	na	na	70	9.8	70	11.1	67.5	10.1	67.5	7.8
75	71.6	22	75	16.0	72.5	13.8	72.5	12.9	72.5	12.3	70	11.7	70	9.7	67.5	8.9
76			na	na	na	na	na	na	na	na	70	8.0	na	na	na	na
77	71.6	23	75	16.2	75	14.5	72.5	12.2	72.5	12.7	70	12.2	67.5	10.1	67.5	8.8
78			72.5	10.2	72.5	10.5	70	8.6	70	9.7	70	10.3	67.5	9.0	accelerometer came loose	accelerometer came loose
79	70.7	23	72.5	13.7	72.5	14.0	70	10.4	70	10.1	70	11.0	67.5	9.2	67.5	8.0
114			72.5	12.7	72.5	12.4	70	11.6	70	11.7	70	12.1	na	na	67.5	6.8
115			72.5	12.1	72.5	12.6	70	9.7	72.5	9.5	70	9.5	67.5	8.0	70	7.1
116	71.6	22	72.5	13.4	75	15.3	72.5	11.7	72.5	12.4	70	11.0	70	8.5	72.5	7.1
117			72.5	13.9	75	12.8	72.5	10.5	70	10.4	70	9.8	70	7.7	72.5	7.1
118			72.5	12.1	72.5	9.8	70	8.4	72.5	8.8	70	8.2	70	7.0	72.5	6.8

Table E-2. Accelerometer Data (“Rework” PWA’s)

Board ID	First Resonance from 1G Sine Sweep (Hz)	Q (from 1G Sine Sweep)	First Resonance @ 9.9Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 12.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 14.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 16.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 18.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 20.0Grms (Hz)	(Response @ First Resonance/Input)*0.5	First Resonance @ 28.0Grms (Hz)	(Response @ First Resonance/Input)*0.5
46			65	11.5	62.5	9.6	62.5	8.3	62.5	7.5	60	7.0	62.5	5.9	62.5	6.3
47	61.8	24	65	12.6	62.5	12.6	62.5	12.2	62.5	11.5	60	9.2	60	7.0	60	7.0
43			65	13.8	60	13.1	60	11.7	62.5	10.2	57.5	9.0	60	8.6	60	8.4
49			65	12.0	62.5	12.5	62.5	11.4	62.5	10.4	60	8.8	60	8.8	62.5	8.0
50	61.8	22	65	13.6	62.5	13.0	62.5	11.1	62.5	10.7	60	8.9	62.5	8.5	62.5	8.0
153			65	13.4	62.5	12.6	62.5	10.9	62.5	11.3	60	9.0	62.5	8.6	62.5	8.3
154	61.8	25	65	13.0	62.5	12.1	62.5	12.3	62.5	11.2	60	10.2	60	8.5	62.5	7.6
155			65	11.3	62.5	12.0	62.5	10.8	62.5	10.4	62.5	8.7	60	8.6	62.5	7.7
156	61.8	23	62.5	11.0	62.5	10.3	62.5	9.5	62.5	9.5	62.5	9.7	60	8.6	62.5	7.2
157			65	11.5	62.5	11.0	62.5	10.1	62.5	10.5	62.5	10.3	62.5	10.4	62.5	7.9
180	62	21	65	13.0	65	13.7	62.5	11.1	62.5	10.9	62.5	10.2	62.5	9.3	62.5	8.1
182	63.9	22	65	11.3	62.5	10.4	62.5	9.5	62.5	10.3	62.5	10.7	62.5	9.9	62.5	7.7
183	62	23	62.5	11.4	62.5	10.9	62.5	10.0	62.5	9.8	62.5	9.8	62.5	9.3	62.5	7.2
184			65	10.1	62.5	10.3	62.5	10.0	62.5	9.9	62.5	9.6	62.5	8.4	62.5	7.7
185			62.5	9.1	60	9.2	60	8.9	62.5	8.6	62.5	8.8	60	7.3	62.5	5.3

Appendix F. Mode Shapes (“Pathfinder” PWA)

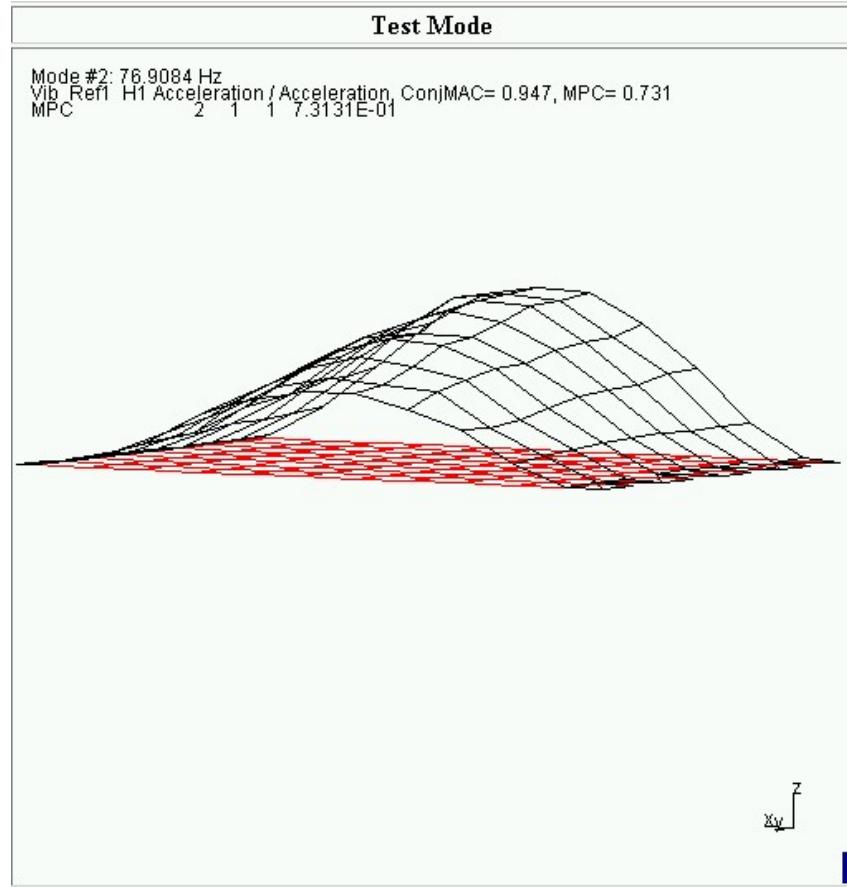
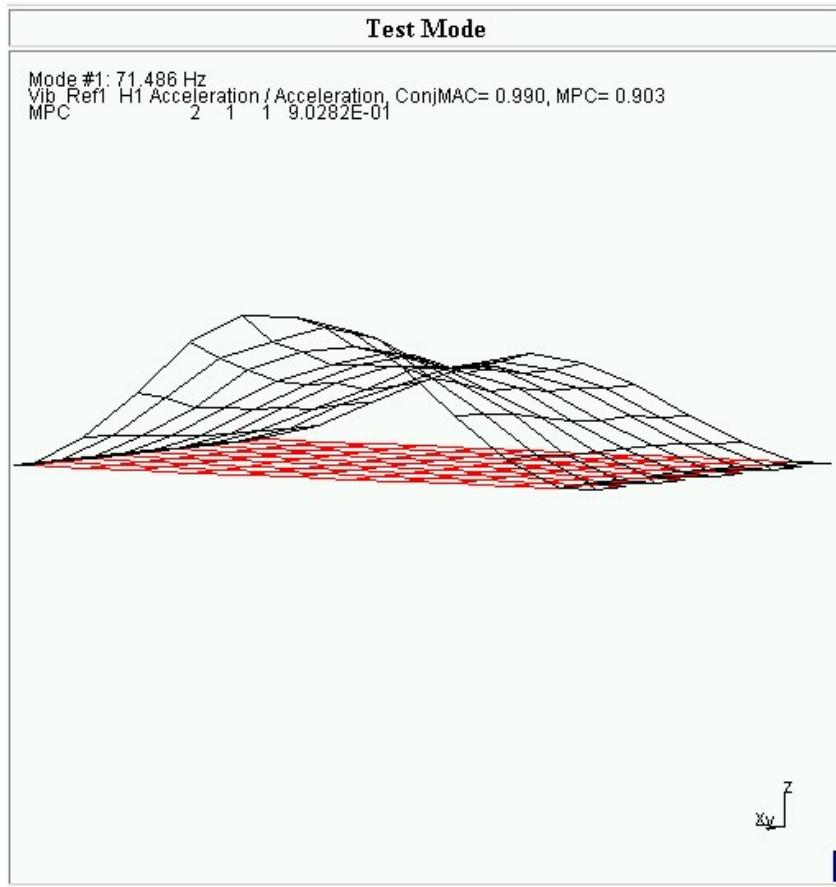


Figure F-1. Mode Shapes (72 Hz and 77 Hz)

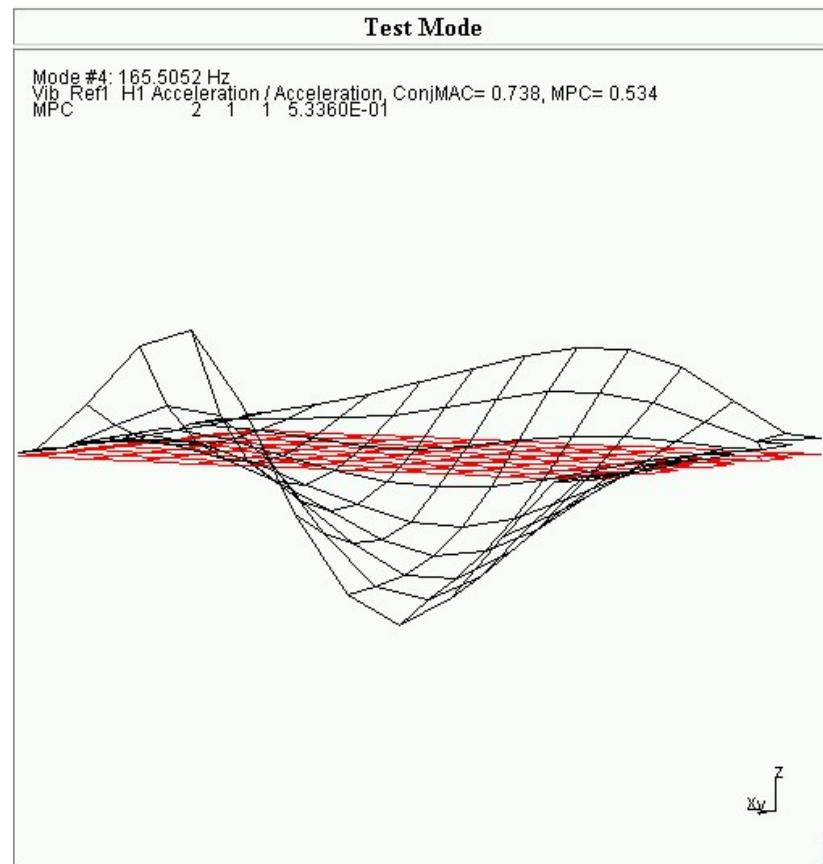
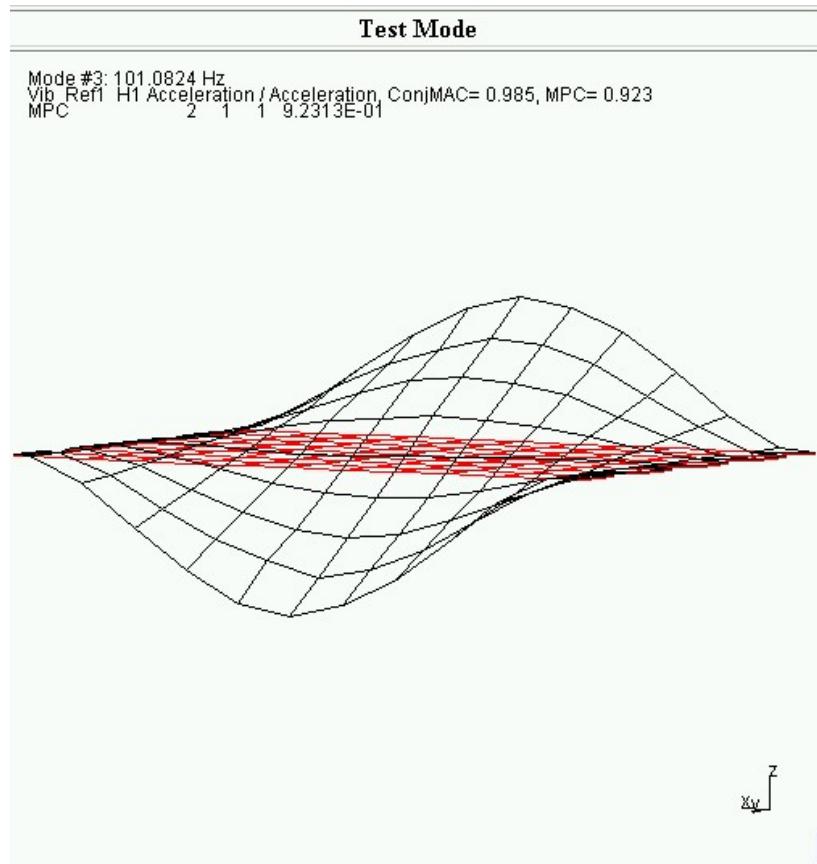


Figure F-2. Mode Shapes (101 Hz and 166 Hz)

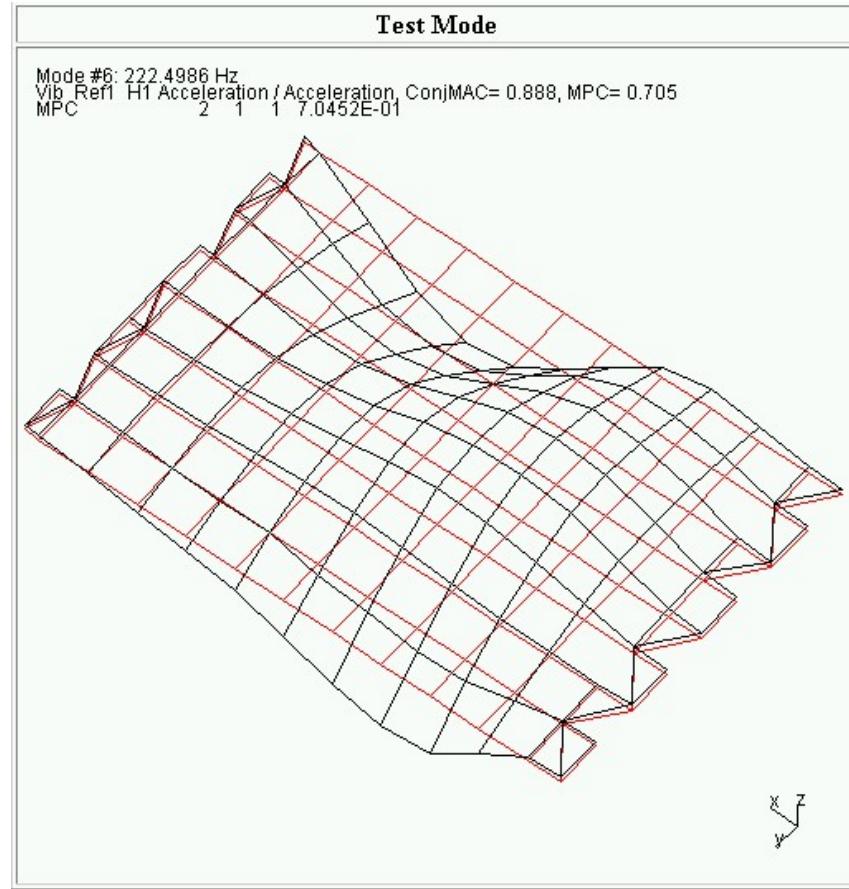
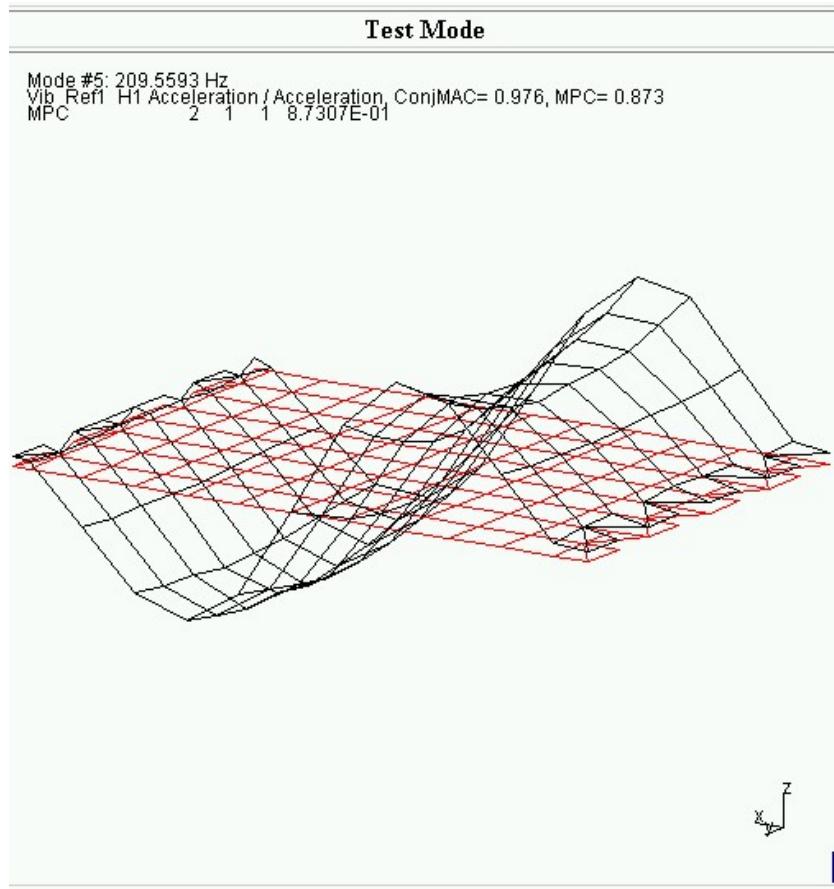


Figure F-3. Mode Shapes (210 Hz and 223 Hz)

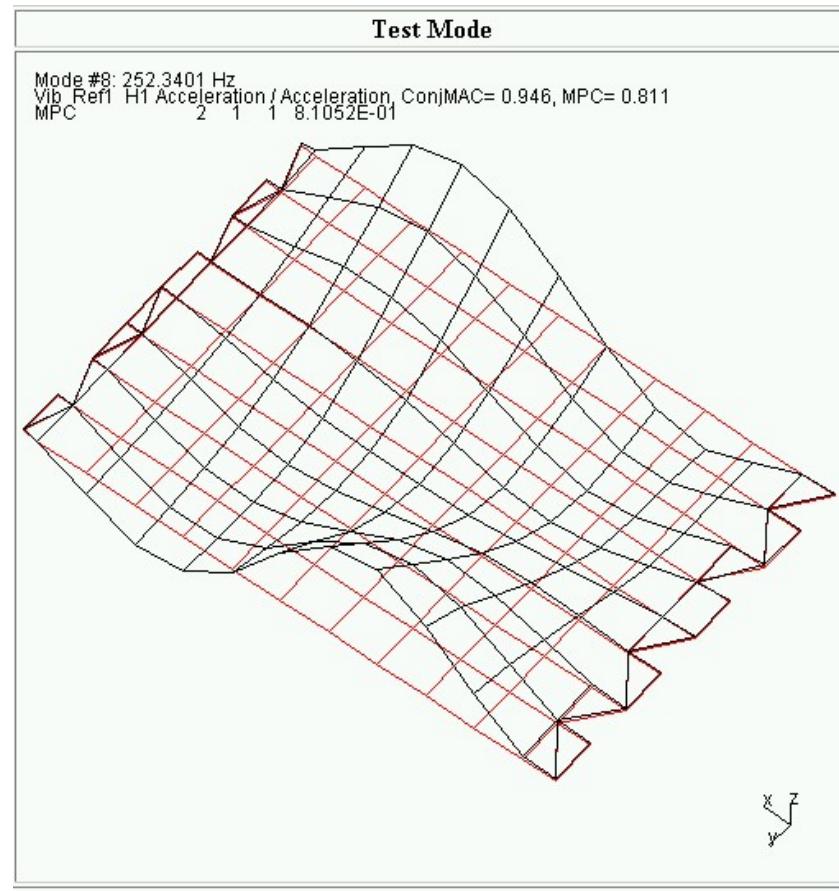
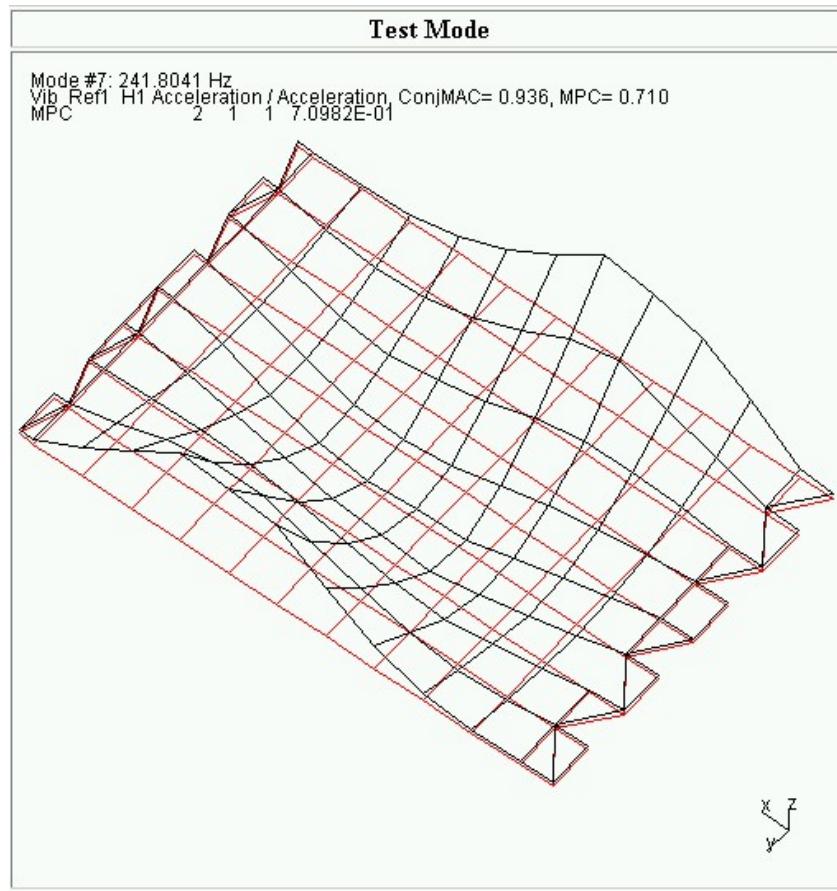


Figure F-4. Mode Shapes (242 Hz and 252 Hz)

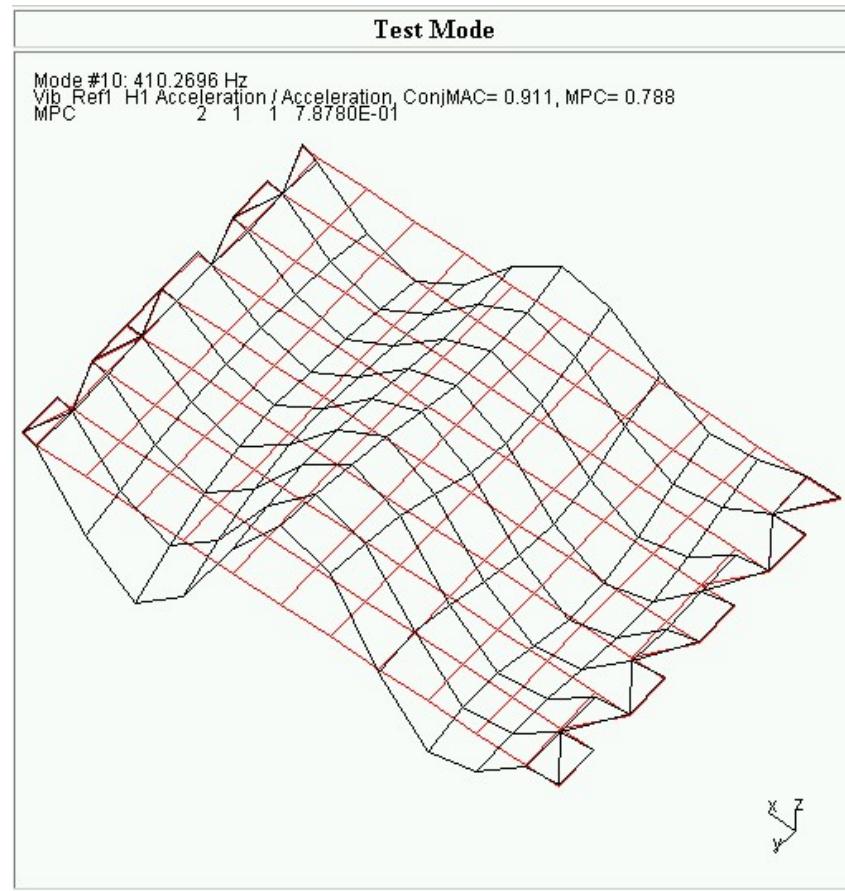
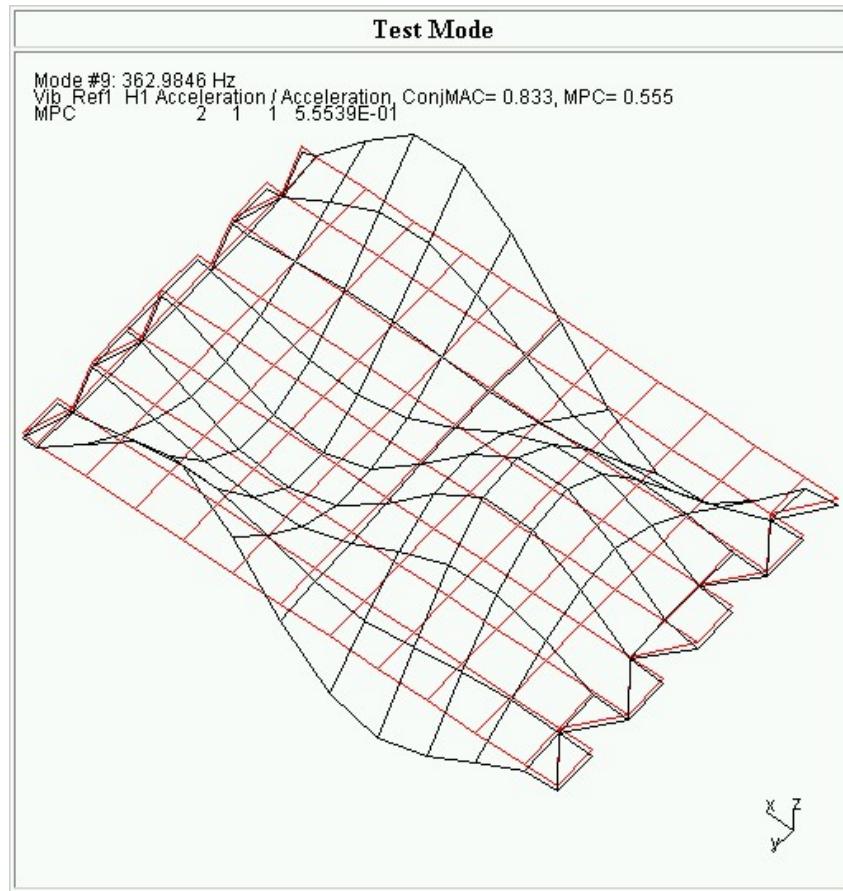


Figure F-5. Mode Shapes (263 Hz and 410 Hz)

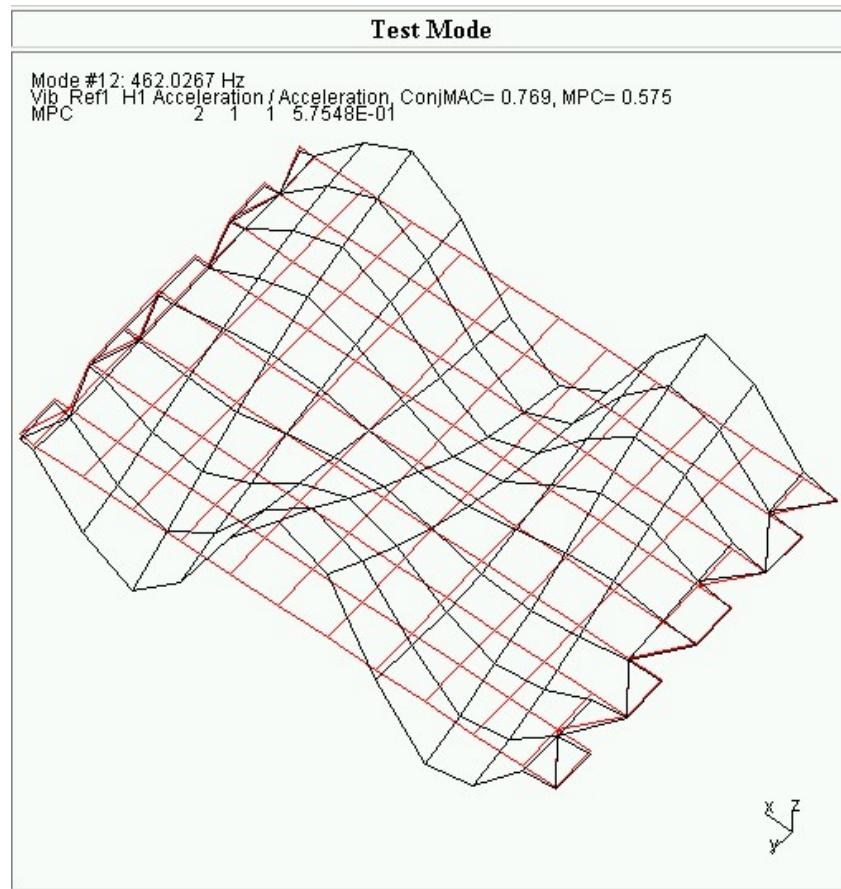
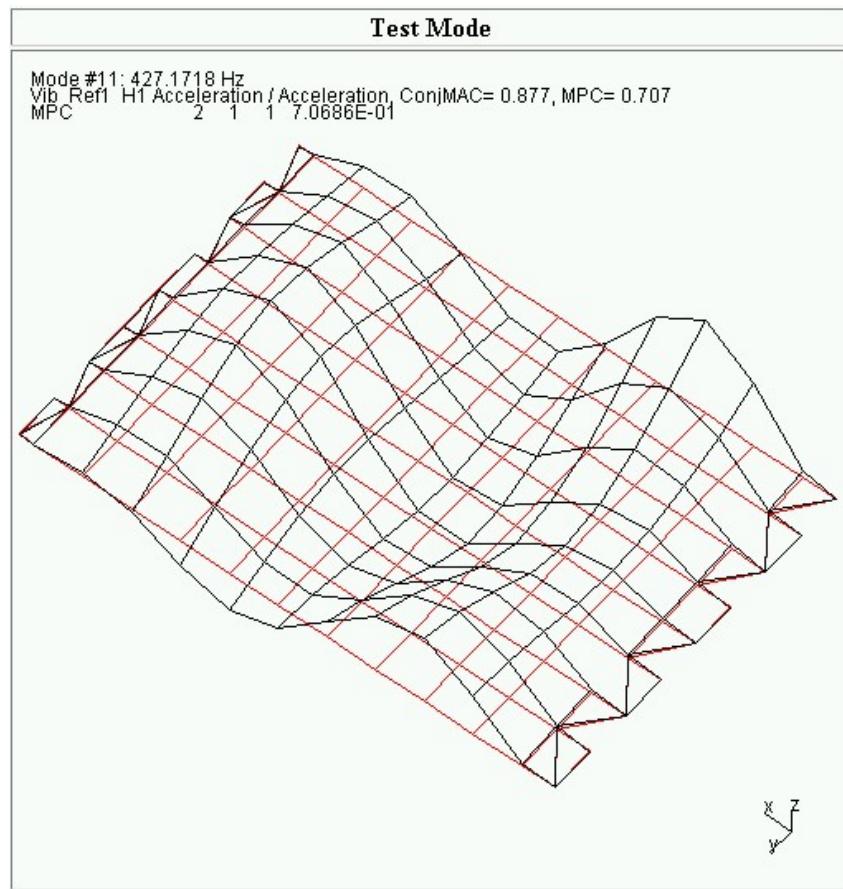


Figure F-6. Mode Shapes (427 Hz and 462 Hz)

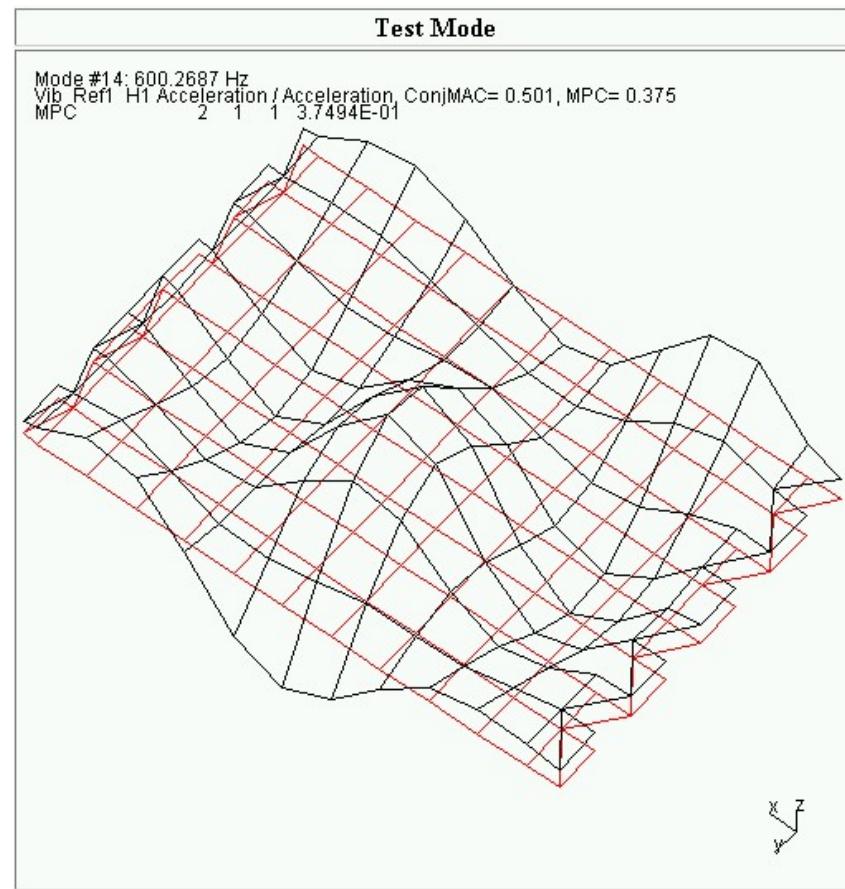
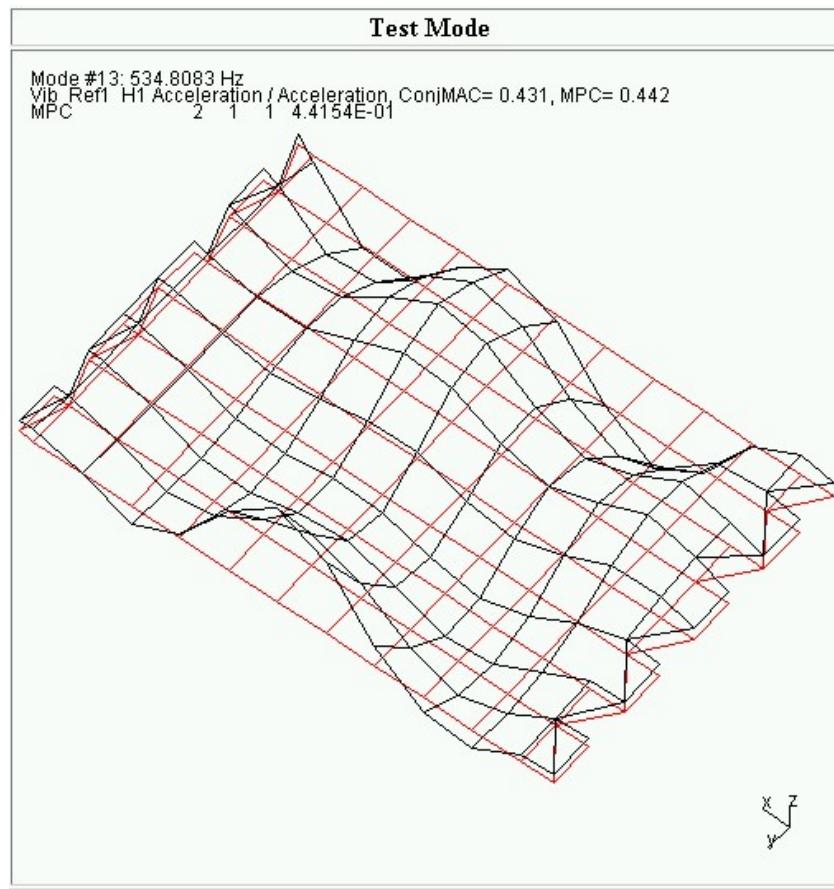


Figure F-7. Mode Shapes (535 Hz and 600 Hz)

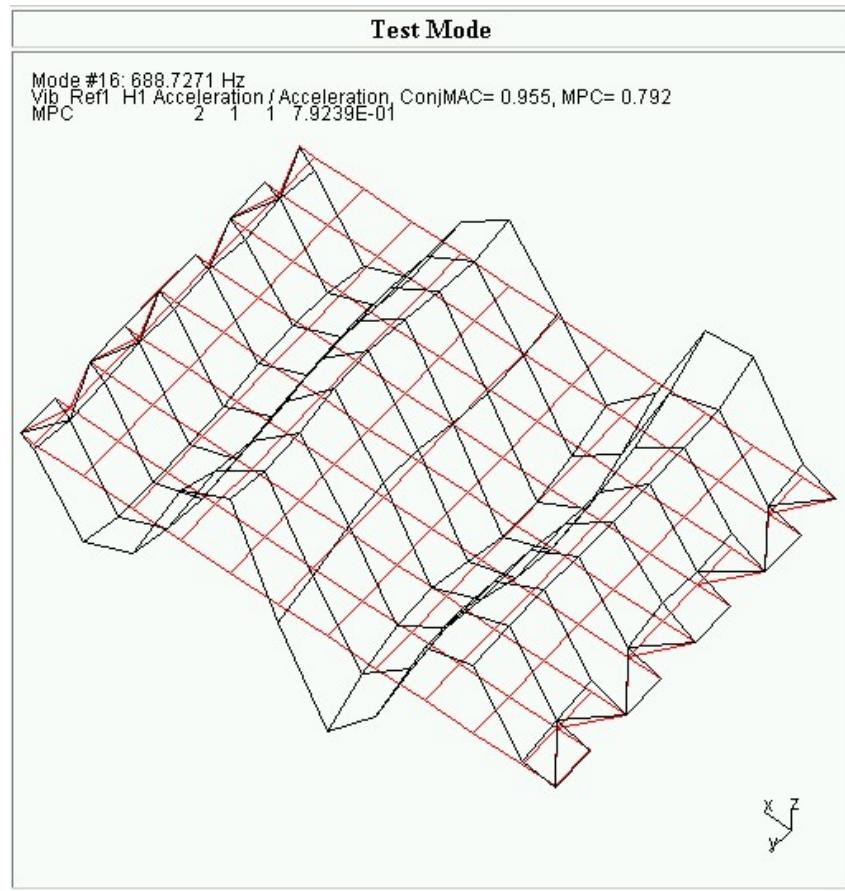
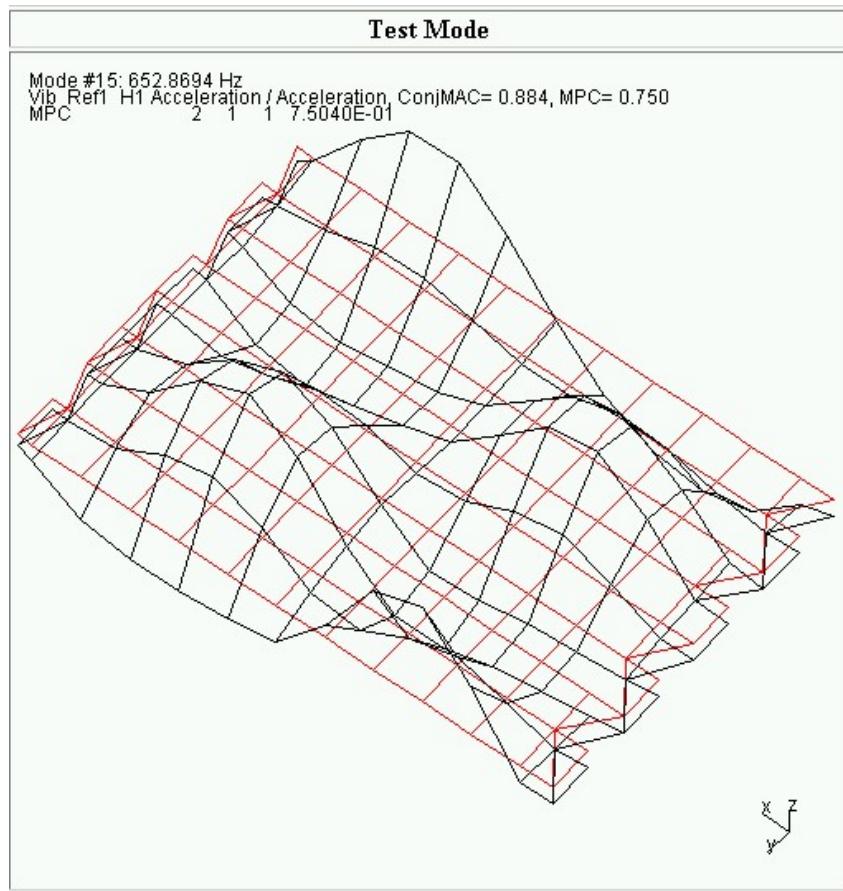


Figure F-8. Mode Shapes (653 Hz and 689 Hz)

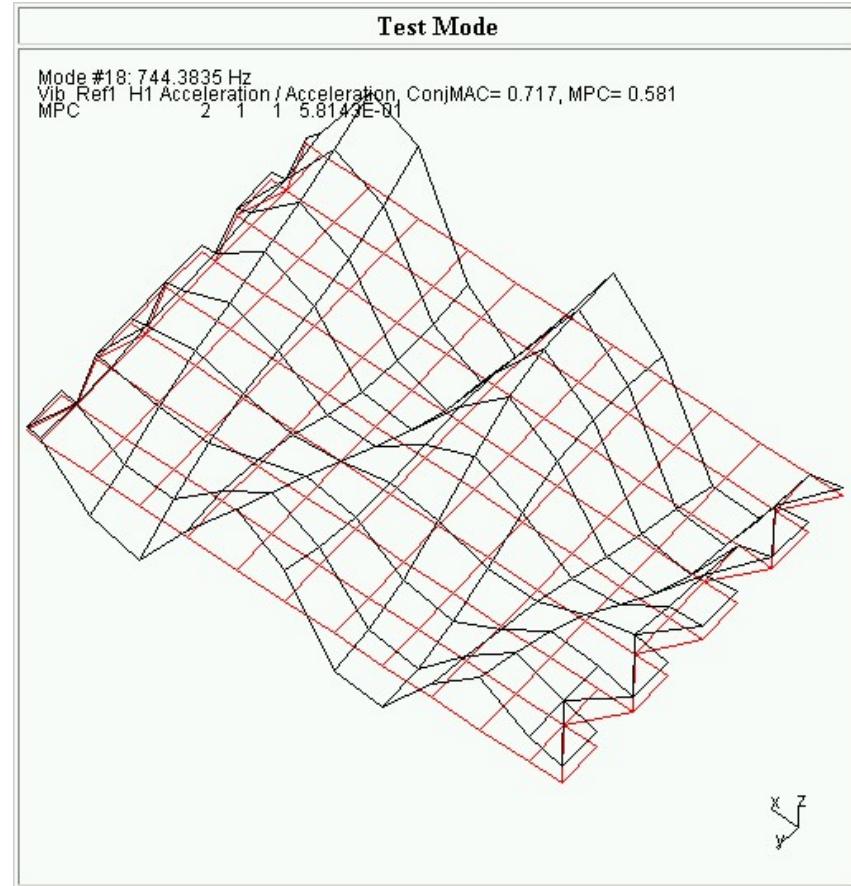
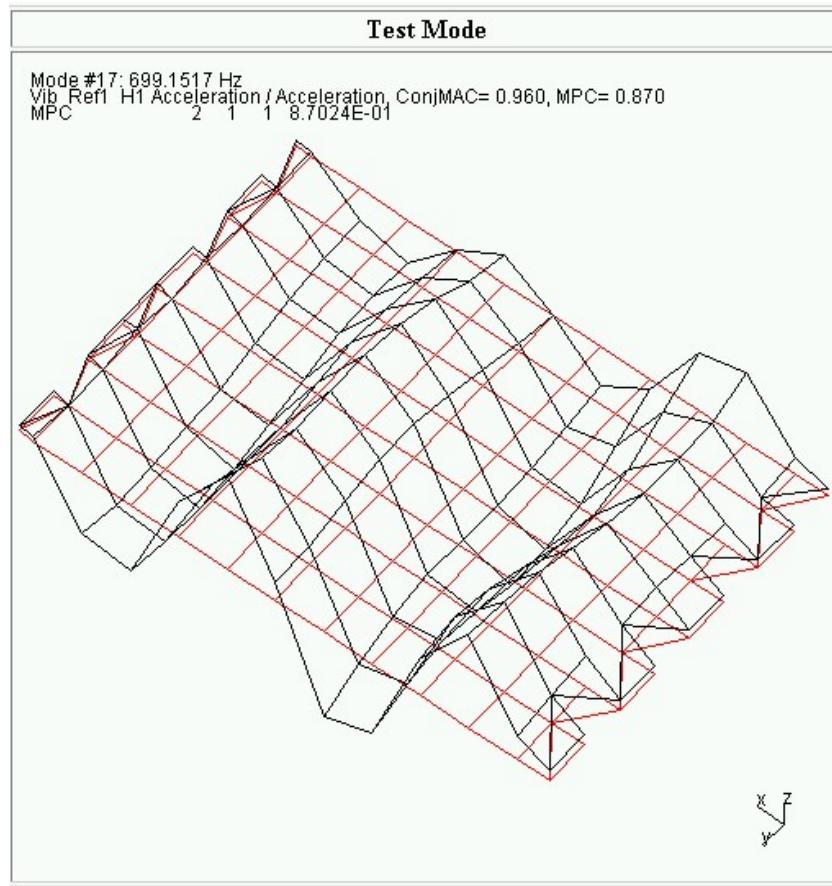


Figure F-9. Mode Shapes (699 Hz and 744 Hz)

**Appendix G. Full Field Strain Calculations
("Pathfinder" PWA)**

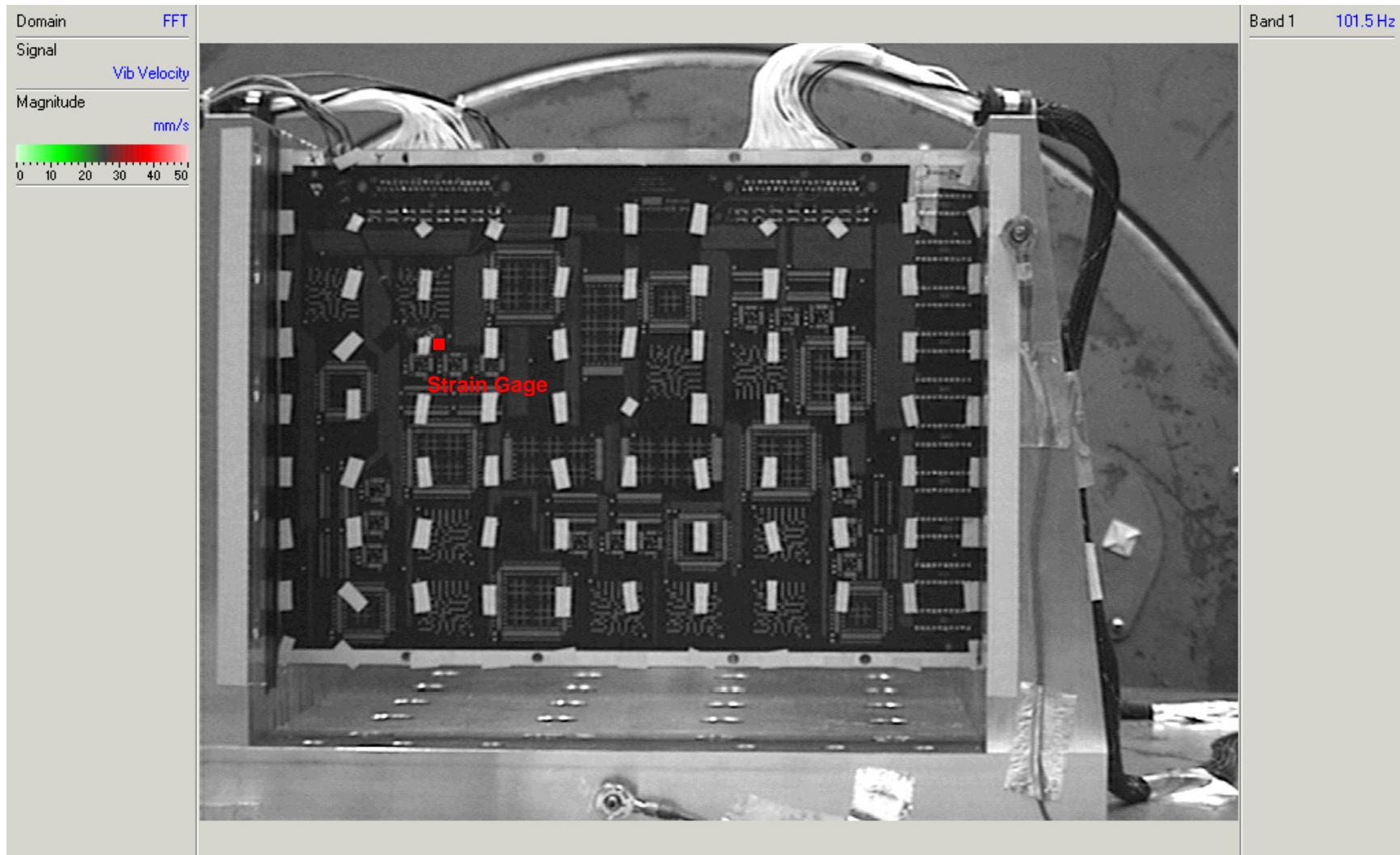


Figure G-1. Laser Vibrometer's View of "Pathfinder" Test Vehicle

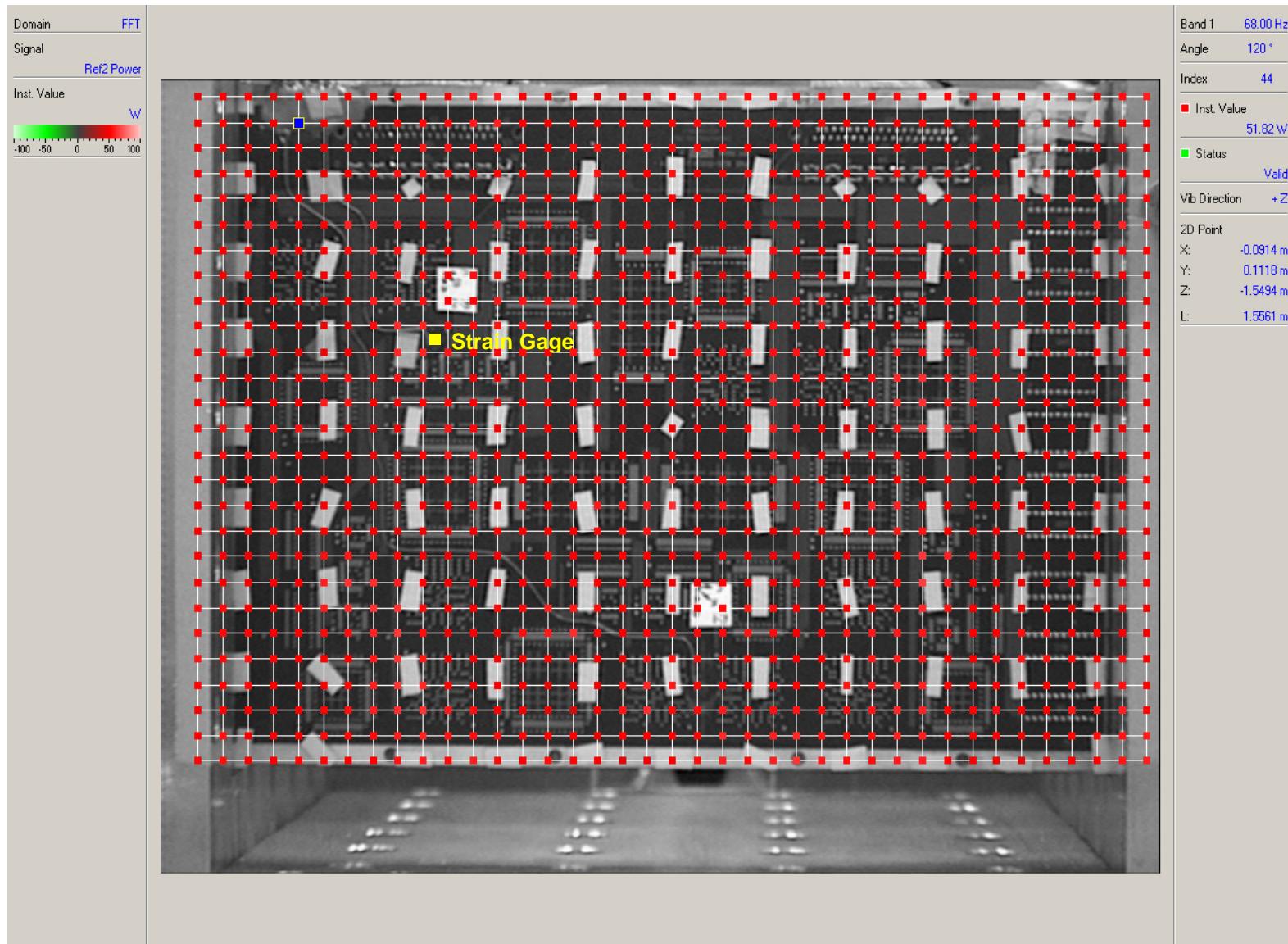


Figure G-2. Laser Vibrometer's View of "Pathfinder" Test Vehicle (Showing Rows and Columns)

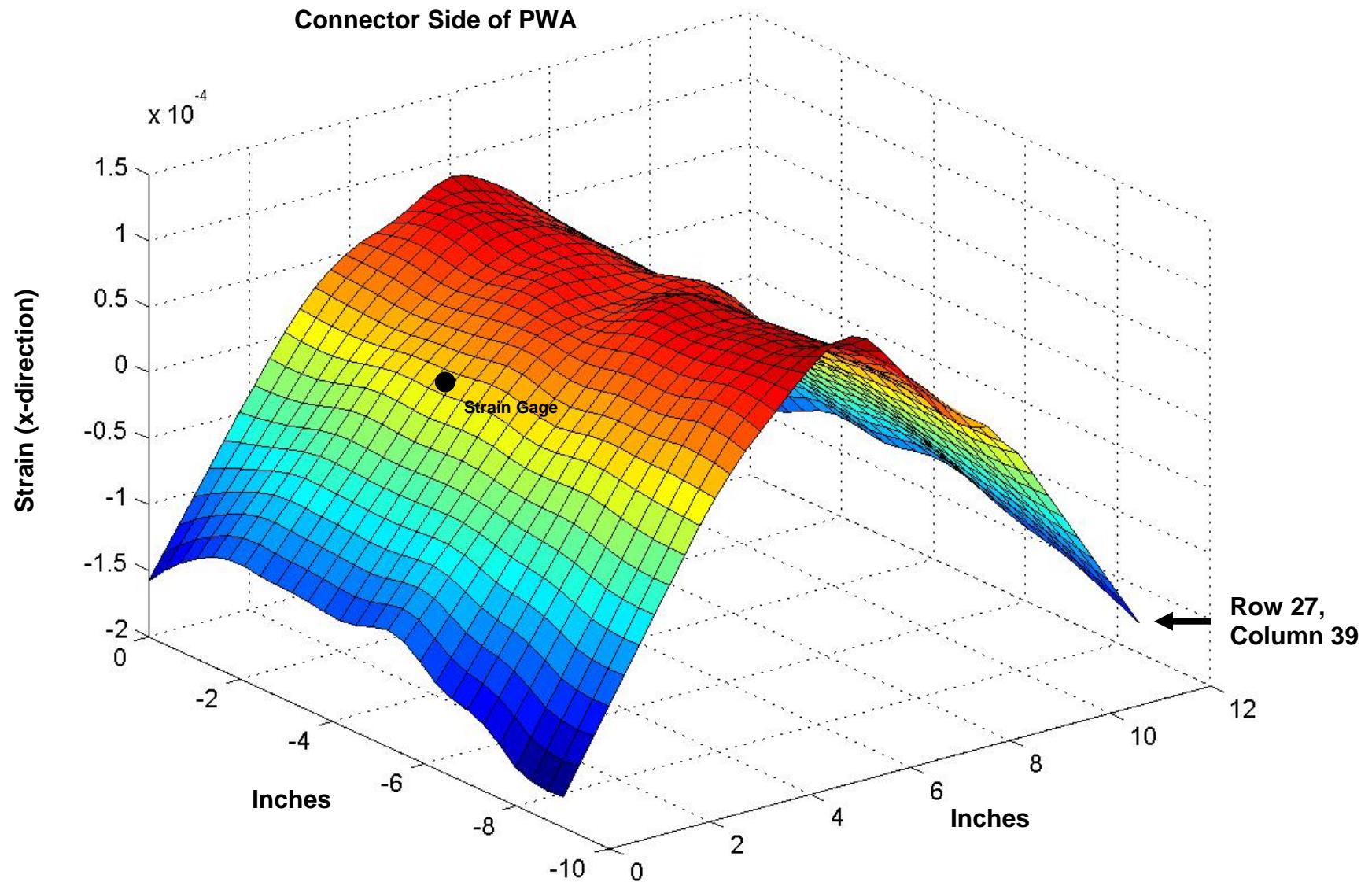


Figure G-3. Full Field Peak Strains at 72 Hz (1 G Sine Dwell, "Pathfinder" PWA)

Table G-1. Calculated Peak Strains at 72 Hz (“Pathfinder” PWA)

Row \ Column	1	2	3	4	5	6	7	8	9	10
1	-1.580E-04	-1.398E-04	-1.215E-04	-1.033E-04	-8.511E-05	-6.690E-05	-4.868E-05	-3.160E-05	-1.400E-05	2.595E-06
2	-1.444E-04	-1.282E-04	-1.119E-04	-9.570E-05	-7.946E-05	-6.322E-05	-4.698E-05	-3.141E-05	-1.504E-05	9.634E-07
3	-1.333E-04	-1.185E-04	-1.038E-04	-8.903E-05	-7.428E-05	-5.953E-05	-4.479E-05	-3.028E-05	-1.489E-05	4.391E-07
4	-1.245E-04	-1.108E-04	-9.704E-05	-8.331E-05	-6.957E-05	-5.583E-05	-4.210E-05	-2.819E-05	-1.355E-05	1.021E-06
5	-1.175E-04	-1.043E-04	-9.110E-05	-7.792E-05	-6.473E-05	-5.155E-05	-3.836E-05	-2.461E-05	-1.059E-05	2.891E-06
6	-1.138E-04	-1.006E-04	-8.743E-05	-7.424E-05	-6.104E-05	-4.785E-05	-3.466E-05	-2.053E-05	-6.713E-06	5.894E-06
7	-1.134E-04	-9.986E-05	-8.630E-05	-7.274E-05	-5.919E-05	-4.563E-05	-3.207E-05	-1.734E-05	-3.353E-06	8.917E-06
8	-1.152E-04	-1.012E-04	-8.724E-05	-7.325E-05	-5.926E-05	-4.527E-05	-3.128E-05	-1.605E-05	-1.670E-06	1.086E-05
9	-1.163E-04	-1.022E-04	-8.815E-05	-7.406E-05	-5.998E-05	-4.589E-05	-3.180E-05	-1.660E-05	-1.993E-06	1.100E-05
10	-1.167E-04	-1.027E-04	-8.870E-05	-7.471E-05	-6.071E-05	-4.672E-05	-3.272E-05	-1.797E-05	-3.329E-06	1.018E-05
11	-1.180E-04	-1.038E-04	-8.969E-05	-7.555E-05	-6.141E-05	-4.727E-05	-3.314E-05	-1.868E-05	-3.853E-06	1.023E-05
12	-1.199E-04	-1.054E-04	-9.085E-05	-7.630E-05	-6.176E-05	-4.721E-05	-3.266E-05	-1.807E-05	-2.921E-06	1.166E-05
13	-1.211E-04	-1.063E-04	-9.140E-05	-7.652E-05	-6.164E-05	-4.676E-05	-3.189E-05	-1.704E-05	-1.713E-06	1.303E-05
14	-1.192E-04	-1.046E-04	-8.995E-05	-7.532E-05	-6.068E-05	-4.605E-05	-3.141E-05	-1.658E-05	-1.600E-06	1.268E-05
15	-1.147E-04	-1.009E-04	-8.705E-05	-7.319E-05	-5.934E-05	-4.549E-05	-3.164E-05	-1.735E-05	-3.170E-06	1.022E-05
16	-1.116E-04	-9.847E-05	-8.537E-05	-7.227E-05	-5.918E-05	-4.608E-05	-3.298E-05	-1.954E-05	-6.104E-06	6.682E-06
17	-1.148E-04	-1.015E-04	-8.824E-05	-7.497E-05	-6.170E-05	-4.844E-05	-3.517E-05	-2.200E-05	-8.431E-06	4.724E-06
18	-1.244E-04	-1.099E-04	-9.541E-05	-8.093E-05	-6.645E-05	-5.197E-05	-3.748E-05	-2.359E-05	-8.881E-06	5.508E-06
19	-1.350E-04	-1.191E-04	-1.032E-04	-8.723E-05	-7.130E-05	-5.536E-05	-3.942E-05	-2.412E-05	-7.946E-06	7.725E-06
20	-1.413E-04	-1.246E-04	-1.078E-04	-9.110E-05	-7.436E-05	-5.763E-05	-4.089E-05	-2.415E-05	-6.943E-06	9.323E-06
21	-1.444E-04	-1.274E-04	-1.105E-04	-9.355E-05	-7.661E-05	-5.968E-05	-4.274E-05	-2.503E-05	-7.302E-06	9.135E-06
22	-1.498E-04	-1.325E-04	-1.152E-04	-9.793E-05	-8.064E-05	-6.335E-05	-4.605E-05	-2.784E-05	-9.636E-06	7.327E-06
23	-1.595E-04	-1.413E-04	-1.231E-04	-1.049E-04	-8.675E-05	-6.856E-05	-5.037E-05	-3.182E-05	-1.287E-05	5.193E-06
24	-1.712E-04	-1.518E-04	-1.323E-04	-1.129E-04	-9.348E-05	-7.405E-05	-5.461E-05	-3.570E-05	-1.586E-05	3.555E-06
25	-1.761E-04	-1.562E-04	-1.363E-04	-1.165E-04	-9.656E-05	-7.667E-05	-5.677E-05	-3.766E-05	-1.754E-05	2.283E-06
26	-1.779E-04	-1.579E-04	-1.379E-04	-1.178E-04	-9.781E-05	-7.778E-05	-5.776E-05	-3.857E-05	-1.847E-05	1.312E-06
27	-1.765E-04	-1.567E-04	-1.369E-04	-1.170E-04	-9.722E-05	-7.740E-05	-5.758E-05	-3.840E-05	-1.865E-05	6.422E-07

Table G-2. Calculated Peak Strains at 72 Hz (“Pathfinder” PWA)

Row \ Column	11	12	13	14	15	16	17	18	19	20
1	1.720E-05	3.026E-05	4.066E-05	4.856E-05	5.481E-05	5.892E-05	6.323E-05	6.929E-05	7.643E-05	8.276E-05
2	1.574E-05	2.892E-05	3.980E-05	4.861E-05	5.621E-05	6.258E-05	6.886E-05	7.462E-05	7.917E-05	8.153E-05
3	1.495E-05	2.787E-05	3.890E-05	4.823E-05	5.671E-05	6.463E-05	7.219E-05	7.773E-05	8.054E-05	8.033E-05
4	1.483E-05	2.712E-05	3.794E-05	4.743E-05	5.633E-05	6.507E-05	7.322E-05	7.861E-05	8.054E-05	7.915E-05
5	1.516E-05	2.614E-05	3.627E-05	4.546E-05	5.423E-05	6.309E-05	7.119E-05	7.682E-05	7.913E-05	7.848E-05
6	1.661E-05	2.621E-05	3.541E-05	4.393E-05	5.209E-05	6.018E-05	6.732E-05	7.285E-05	7.600E-05	7.705E-05
7	1.873E-05	2.746E-05	3.602E-05	4.403E-05	5.160E-05	5.861E-05	6.433E-05	6.913E-05	7.272E-05	7.505E-05
8	2.071E-05	2.934E-05	3.778E-05	4.579E-05	5.322E-05	5.955E-05	6.416E-05	6.782E-05	7.097E-05	7.325E-05
9	2.151E-05	3.054E-05	3.940E-05	4.799E-05	5.589E-05	6.242E-05	6.688E-05	6.954E-05	7.156E-05	7.246E-05
10	2.164E-05	3.142E-05	4.101E-05	5.025E-05	5.843E-05	6.514E-05	6.957E-05	7.129E-05	7.187E-05	7.116E-05
11	2.256E-05	3.310E-05	4.315E-05	5.225E-05	5.967E-05	6.551E-05	6.911E-05	6.994E-05	6.948E-05	6.814E-05
12	2.454E-05	3.559E-05	4.556E-05	5.365E-05	5.938E-05	6.328E-05	6.532E-05	6.560E-05	6.505E-05	6.446E-05
13	2.611E-05	3.744E-05	4.712E-05	5.419E-05	5.849E-05	6.074E-05	6.177E-05	6.241E-05	6.278E-05	6.357E-05
14	2.539E-05	3.655E-05	4.605E-05	5.304E-05	5.753E-05	6.009E-05	6.208E-05	6.440E-05	6.635E-05	6.809E-05
15	2.225E-05	3.306E-05	4.283E-05	5.093E-05	5.726E-05	6.202E-05	6.653E-05	7.095E-05	7.428E-05	7.613E-05
16	1.840E-05	2.933E-05	4.013E-05	5.019E-05	5.902E-05	6.643E-05	7.309E-05	7.840E-05	8.176E-05	8.275E-05
17	1.687E-05	2.838E-05	4.028E-05	5.181E-05	6.216E-05	7.089E-05	7.782E-05	8.224E-05	8.434E-05	8.439E-05
18	1.855E-05	3.059E-05	4.291E-05	5.471E-05	6.514E-05	7.349E-05	7.904E-05	8.160E-05	8.217E-05	8.196E-05
19	2.149E-05	3.353E-05	4.538E-05	5.660E-05	6.646E-05	7.404E-05	7.847E-05	8.003E-05	8.001E-05	8.016E-05
20	2.322E-05	3.474E-05	4.571E-05	5.639E-05	6.610E-05	7.385E-05	7.885E-05	8.105E-05	8.146E-05	8.166E-05
21	2.313E-05	3.451E-05	4.524E-05	5.597E-05	6.595E-05	7.434E-05	8.066E-05	8.409E-05	8.520E-05	8.476E-05
22	2.220E-05	3.469E-05	4.646E-05	5.782E-05	6.791E-05	7.635E-05	8.315E-05	8.711E-05	8.843E-05	8.699E-05
23	2.164E-05	3.614E-05	4.967E-05	6.167E-05	7.138E-05	7.899E-05	8.507E-05	8.874E-05	8.992E-05	8.779E-05
24	2.167E-05	3.813E-05	5.329E-05	6.563E-05	7.476E-05	8.133E-05	8.631E-05	8.955E-05	9.077E-05	8.877E-05
25	2.081E-05	3.775E-05	5.329E-05	6.572E-05	7.523E-05	8.258E-05	8.850E-05	9.305E-05	9.542E-05	9.409E-05
26	1.959E-05	3.617E-05	5.138E-05	6.366E-05	7.404E-05	8.314E-05	9.105E-05	9.787E-05	1.021E-04	1.021E-04
27	1.800E-05	3.338E-05	4.754E-05	5.946E-05	7.118E-05	8.300E-05	9.394E-05	1.040E-04	1.108E-04	1.127E-04

Table G-3. Calculated Peak Strains at 72 Hz (“Pathfinder” PWA)

Row \ Column	21	22	23	24	25	26	27	28	29	30
1	8.608E-05	8.411E-05	7.803E-05	7.057E-05	6.230E-05	5.204E-05	3.855E-05	2.474E-05	1.052E-05	-3.925E-06
2	8.103E-05	7.784E-05	7.290E-05	6.679E-05	5.975E-05	5.014E-05	3.769E-05	2.555E-05	1.328E-05	-1.208E-06
3	7.741E-05	7.348E-05	6.925E-05	6.393E-05	5.759E-05	4.847E-05	3.696E-05	2.606E-05	1.516E-05	8.088E-07
4	7.521E-05	7.104E-05	6.707E-05	6.200E-05	5.581E-05	4.704E-05	3.635E-05	2.627E-05	1.618E-05	2.126E-06
5	7.539E-05	7.147E-05	6.686E-05	6.106E-05	5.421E-05	4.569E-05	3.597E-05	2.622E-05	1.609E-05	2.609E-06
6	7.587E-05	7.283E-05	6.780E-05	6.126E-05	5.348E-05	4.489E-05	3.558E-05	2.570E-05	1.524E-05	2.416E-06
7	7.539E-05	7.314E-05	6.808E-05	6.122E-05	5.279E-05	4.405E-05	3.478E-05	2.492E-05	1.441E-05	2.105E-06
8	7.368E-05	7.157E-05	6.679E-05	6.005E-05	5.158E-05	4.293E-05	3.379E-05	2.445E-05	1.437E-05	2.196E-06
9	7.167E-05	6.899E-05	6.440E-05	5.792E-05	4.995E-05	4.194E-05	3.361E-05	2.514E-05	1.527E-05	2.725E-06
10	6.938E-05	6.673E-05	6.273E-05	5.687E-05	4.985E-05	4.278E-05	3.544E-05	2.718E-05	1.637E-05	3.200E-06
11	6.683E-05	6.568E-05	6.317E-05	5.855E-05	5.268E-05	4.625E-05	3.903E-05	2.969E-05	1.684E-05	3.184E-06
12	6.489E-05	6.606E-05	6.555E-05	6.260E-05	5.765E-05	5.096E-05	4.234E-05	3.082E-05	1.589E-05	2.283E-06
13	6.527E-05	6.743E-05	6.785E-05	6.591E-05	6.108E-05	5.316E-05	4.214E-05	2.880E-05	1.365E-05	8.847E-07
14	6.920E-05	6.964E-05	6.870E-05	6.605E-05	6.028E-05	5.081E-05	3.784E-05	2.430E-05	1.136E-05	-2.274E-07
15	7.528E-05	7.231E-05	6.839E-05	6.354E-05	5.632E-05	4.590E-05	3.243E-05	1.997E-05	9.953E-06	-7.673E-07
16	7.995E-05	7.411E-05	6.744E-05	6.019E-05	5.186E-05	4.184E-05	2.964E-05	1.856E-05	1.011E-05	-5.725E-07
17	8.117E-05	7.472E-05	6.704E-05	5.828E-05	4.948E-05	4.090E-05	3.112E-05	2.109E-05	1.220E-05	4.950E-07
18	7.995E-05	7.490E-05	6.777E-05	5.854E-05	4.957E-05	4.247E-05	3.509E-05	2.559E-05	1.497E-05	1.750E-06
19	7.940E-05	7.574E-05	6.915E-05	5.968E-05	5.009E-05	4.322E-05	3.715E-05	2.831E-05	1.679E-05	2.626E-06
20	8.075E-05	7.716E-05	7.039E-05	6.069E-05	5.040E-05	4.255E-05	3.649E-05	2.845E-05	1.736E-05	3.014E-06
21	8.260E-05	7.844E-05	7.150E-05	6.225E-05	5.216E-05	4.307E-05	3.580E-05	2.760E-05	1.682E-05	2.673E-06
22	8.361E-05	7.919E-05	7.275E-05	6.467E-05	5.575E-05	4.604E-05	3.714E-05	2.755E-05	1.610E-05	1.946E-06
23	8.402E-05	7.992E-05	7.446E-05	6.767E-05	6.014E-05	5.050E-05	4.022E-05	2.870E-05	1.598E-05	1.340E-06
24	8.538E-05	8.152E-05	7.657E-05	7.020E-05	6.317E-05	5.377E-05	4.273E-05	2.980E-05	1.632E-05	9.409E-07
25	9.036E-05	8.485E-05	7.816E-05	7.003E-05	6.134E-05	5.124E-05	4.006E-05	2.788E-05	1.641E-05	8.691E-07
26	9.782E-05	8.952E-05	7.962E-05	6.813E-05	5.621E-05	4.494E-05	3.417E-05	2.415E-05	1.648E-05	1.046E-06
27	1.078E-04	9.552E-05	8.092E-05	6.450E-05	4.779E-05	3.486E-05	2.507E-05	1.862E-05	1.654E-05	1.473E-06

Table G-4. Calculated Peak Strains at 72 Hz (“Pathfinder” PWA)

Row \ Column	31	32	33	34	35	36	37	38	39
1	-1.832E-05	-3.252E-05	-4.672E-05	-6.091E-05	-7.511E-05	-8.931E-05	-1.035E-04	-1.177E-04	-1.319E-04
2	-1.481E-05	-2.964E-05	-4.446E-05	-5.929E-05	-7.411E-05	-8.894E-05	-1.038E-04	-1.186E-04	-1.334E-04
3	-1.214E-05	-2.725E-05	-4.236E-05	-5.747E-05	-7.258E-05	-8.769E-05	-1.028E-04	-1.179E-04	-1.330E-04
4	-1.030E-05	-2.535E-05	-4.040E-05	-5.545E-05	-7.050E-05	-8.555E-05	-1.006E-04	-1.156E-04	-1.307E-04
5	-9.406E-06	-2.395E-05	-3.848E-05	-5.302E-05	-6.756E-05	-8.210E-05	-9.664E-05	-1.112E-04	-1.257E-04
6	-9.374E-06	-2.311E-05	-3.685E-05	-5.058E-05	-6.432E-05	-7.805E-05	-9.179E-05	-1.055E-04	-1.193E-04
7	-9.657E-06	-2.264E-05	-3.562E-05	-4.860E-05	-6.158E-05	-7.455E-05	-8.753E-05	-1.005E-04	-1.135E-04
8	-9.793E-06	-2.241E-05	-3.503E-05	-4.765E-05	-6.027E-05	-7.289E-05	-8.551E-05	-9.813E-05	-1.108E-04
9	-9.898E-06	-2.261E-05	-3.531E-05	-4.802E-05	-6.073E-05	-7.344E-05	-8.615E-05	-9.885E-05	-1.116E-04
10	-1.042E-05	-2.336E-05	-3.631E-05	-4.925E-05	-6.219E-05	-7.513E-05	-8.808E-05	-1.010E-04	-1.140E-04
11	-1.144E-05	-2.443E-05	-3.742E-05	-5.040E-05	-6.339E-05	-7.637E-05	-8.936E-05	-1.023E-04	-1.153E-04
12	-1.274E-05	-2.542E-05	-3.809E-05	-5.077E-05	-6.344E-05	-7.611E-05	-8.879E-05	-1.015E-04	-1.141E-04
13	-1.326E-05	-2.548E-05	-3.770E-05	-4.992E-05	-6.214E-05	-7.436E-05	-8.658E-05	-9.880E-05	-1.110E-04
14	-1.245E-05	-2.454E-05	-3.662E-05	-4.870E-05	-6.079E-05	-7.287E-05	-8.496E-05	-9.704E-05	-1.091E-04
15	-1.124E-05	-2.354E-05	-3.584E-05	-4.814E-05	-6.044E-05	-7.274E-05	-8.504E-05	-9.733E-05	-1.096E-04
16	-1.061E-05	-2.330E-05	-3.599E-05	-4.868E-05	-6.137E-05	-7.406E-05	-8.674E-05	-9.943E-05	-1.121E-04
17	-1.075E-05	-2.402E-05	-3.729E-05	-5.057E-05	-6.384E-05	-7.711E-05	-9.039E-05	-1.037E-04	-1.169E-04
18	-1.150E-05	-2.536E-05	-3.922E-05	-5.308E-05	-6.694E-05	-8.080E-05	-9.466E-05	-1.085E-04	-1.224E-04
19	-1.180E-05	-2.615E-05	-4.051E-05	-5.486E-05	-6.922E-05	-8.357E-05	-9.792E-05	-1.123E-04	-1.266E-04
20	-1.135E-05	-2.623E-05	-4.112E-05	-5.601E-05	-7.089E-05	-8.578E-05	-1.007E-04	-1.155E-04	-1.304E-04
21	-1.122E-05	-2.650E-05	-4.178E-05	-5.706E-05	-7.234E-05	-8.762E-05	-1.029E-04	-1.182E-04	-1.335E-04
22	-1.199E-05	-2.755E-05	-4.312E-05	-5.869E-05	-7.426E-05	-8.983E-05	-1.054E-04	-1.210E-04	-1.365E-04
23	-1.330E-05	-2.925E-05	-4.520E-05	-6.115E-05	-7.710E-05	-9.305E-05	-1.090E-04	-1.249E-04	-1.409E-04
24	-1.450E-05	-3.098E-05	-4.745E-05	-6.393E-05	-8.040E-05	-9.687E-05	-1.133E-04	-1.298E-04	-1.463E-04
25	-1.401E-05	-3.121E-05	-4.841E-05	-6.562E-05	-8.282E-05	-1.000E-04	-1.172E-04	-1.344E-04	-1.516E-04
26	-1.248E-05	-3.059E-05	-4.869E-05	-6.679E-05	-8.490E-05	-1.030E-04	-1.211E-04	-1.392E-04	-1.573E-04
27	-9.936E-06	-2.911E-05	-4.828E-05	-6.745E-05	-8.662E-05	-1.058E-04	-1.250E-04	-1.441E-04	-1.633E-04

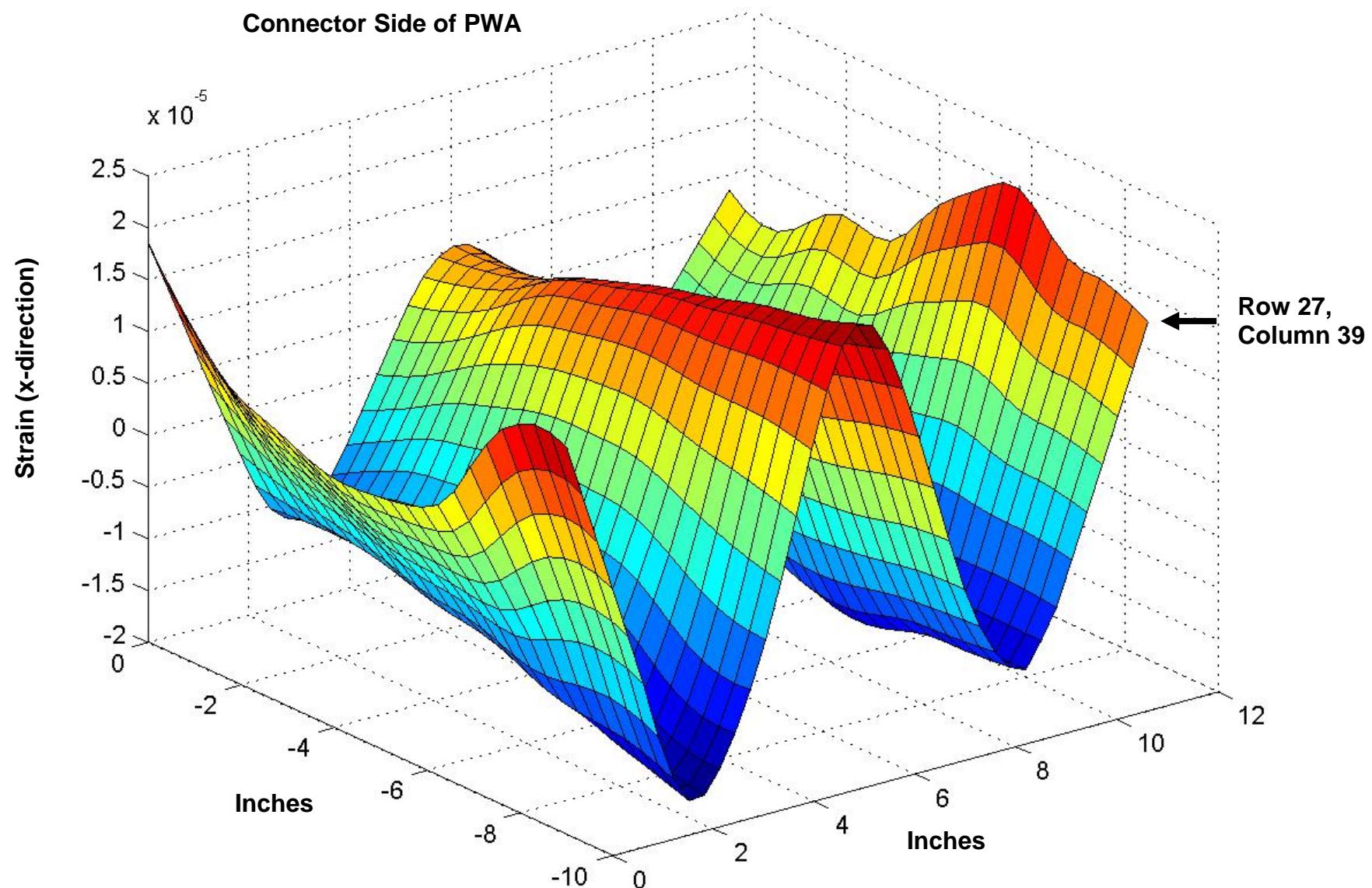


Figure G-4. Full Field Peak Strains at 411 Hz (1 G Sine Dwell, "Pathfinder" PWA)

Table G-5. Calculated Peak Strains at 411 Hz (“Pathfinder” PWA)

Row \ Column	1	2	3	4	5	6	7	8	9	10
1	1.848E-05	1.469E-05	1.090E-05	7.102E-06	3.308E-06	-4.860E-07	-4.242E-06	-7.736E-06	-1.039E-05	-1.168E-05
2	1.603E-05	1.257E-05	9.107E-06	5.643E-06	2.180E-06	-1.284E-06	-4.776E-06	-7.931E-06	-1.021E-05	-1.117E-05
3	1.379E-05	1.063E-05	7.466E-06	4.302E-06	1.138E-06	-2.025E-06	-5.276E-06	-8.132E-06	-1.009E-05	-1.075E-05
4	1.176E-05	8.869E-06	5.974E-06	3.079E-06	1.842E-07	-2.711E-06	-5.741E-06	-8.339E-06	-1.002E-05	-1.043E-05
5	9.783E-06	7.148E-06	4.512E-06	1.877E-06	-7.589E-07	-3.394E-06	-6.201E-06	-8.561E-06	-9.997E-06	-1.016E-05
6	8.265E-06	5.825E-06	3.384E-06	9.430E-07	-1.498E-06	-3.939E-06	-6.579E-06	-8.773E-06	-1.004E-05	-1.003E-05
7	7.244E-06	4.928E-06	2.612E-06	2.959E-07	-2.020E-06	-4.336E-06	-6.885E-06	-8.986E-06	-1.016E-05	-1.004E-05
8	6.636E-06	4.383E-06	2.130E-06	-1.237E-07	-2.377E-06	-4.631E-06	-7.164E-06	-9.223E-06	-1.035E-05	-1.016E-05
9	6.029E-06	3.818E-06	1.607E-06	-6.040E-07	-2.815E-06	-5.026E-06	-7.578E-06	-9.590E-06	-1.062E-05	-1.030E-05
10	5.332E-06	3.156E-06	9.787E-07	-1.198E-06	-3.375E-06	-5.552E-06	-8.113E-06	-1.006E-05	-1.097E-05	-1.047E-05
11	4.625E-06	2.471E-06	3.181E-07	-1.835E-06	-3.989E-06	-6.142E-06	-8.702E-06	-1.059E-05	-1.135E-05	-1.065E-05
12	4.114E-06	1.960E-06	-1.942E-07	-2.349E-06	-4.503E-06	-6.657E-06	-9.217E-06	-1.106E-05	-1.173E-05	-1.088E-05
13	3.875E-06	1.698E-06	-4.785E-07	-2.655E-06	-4.832E-06	-7.009E-06	-9.574E-06	-1.142E-05	-1.207E-05	-1.116E-05
14	3.905E-06	1.686E-06	-5.332E-07	-2.753E-06	-4.972E-06	-7.191E-06	-9.773E-06	-1.166E-05	-1.234E-05	-1.147E-05
15	4.089E-06	1.800E-06	-4.885E-07	-2.778E-06	-5.067E-06	-7.356E-06	-9.986E-06	-1.193E-05	-1.267E-05	-1.185E-05
16	4.313E-06	1.923E-06	-4.665E-07	-2.856E-06	-5.246E-06	-7.636E-06	-1.037E-05	-1.238E-05	-1.317E-05	-1.234E-05
17	4.601E-06	2.075E-06	-4.517E-07	-2.979E-06	-5.505E-06	-8.032E-06	-1.094E-05	-1.306E-05	-1.384E-05	-1.290E-05
18	5.083E-06	2.386E-06	-3.115E-07	-3.009E-06	-5.707E-06	-8.404E-06	-1.158E-05	-1.383E-05	-1.459E-05	-1.347E-05
19	5.994E-06	3.086E-06	1.792E-07	-2.728E-06	-5.636E-06	-8.543E-06	-1.203E-05	-1.449E-05	-1.530E-05	-1.409E-05
20	7.999E-06	4.748E-06	1.496E-06	-1.756E-06	-5.007E-06	-8.259E-06	-1.215E-05	-1.495E-05	-1.602E-05	-1.492E-05
21	1.108E-05	7.346E-06	3.612E-06	-1.217E-07	-3.856E-06	-7.589E-06	-1.195E-05	-1.525E-05	-1.677E-05	-1.601E-05
22	1.397E-05	9.802E-06	5.633E-06	1.463E-06	-2.706E-06	-6.876E-06	-1.163E-05	-1.540E-05	-1.741E-05	-1.707E-05
23	1.617E-05	1.166E-05	7.160E-06	2.655E-06	-1.850E-06	-6.354E-06	-1.141E-05	-1.555E-05	-1.795E-05	-1.797E-05
24	1.735E-05	1.265E-05	7.943E-06	3.237E-06	-1.468E-06	-6.173E-06	-1.142E-05	-1.579E-05	-1.841E-05	-1.861E-05
25	1.802E-05	1.315E-05	8.287E-06	3.422E-06	-1.442E-06	-6.307E-06	-1.173E-05	-1.623E-05	-1.894E-05	-1.917E-05
26	1.798E-05	1.303E-05	8.087E-06	3.142E-06	-1.802E-06	-6.746E-06	-1.228E-05	-1.681E-05	-1.945E-05	-1.957E-05
27	1.723E-05	1.229E-05	7.342E-06	2.398E-06	-2.546E-06	-7.490E-06	-1.307E-05	-1.752E-05	-1.997E-05	-1.982E-05

Table G-6. Calculated Peak Strains at 411 Hz (“Pathfinder” PWA)

Row \ Column	11	12	13	14	15	16	17	18	19	20
1	-1.170E-05	-1.065E-05	-8.761E-06	-6.252E-06	-3.302E-06	-2.830E-07	2.742E-06	5.611E-06	7.954E-06	9.481E-06
2	-1.096E-05	-9.777E-06	-7.842E-06	-5.367E-06	-2.577E-06	2.823E-07	3.207E-06	5.978E-06	8.238E-06	9.659E-06
3	-1.032E-05	-9.002E-06	-7.001E-06	-4.514E-06	-1.803E-06	9.698E-07	3.818E-06	6.475E-06	8.612E-06	9.899E-06
4	-9.778E-06	-8.325E-06	-6.239E-06	-3.694E-06	-9.809E-07	1.779E-06	4.574E-06	7.103E-06	9.075E-06	1.020E-05
5	-9.297E-06	-7.690E-06	-5.484E-06	-2.817E-06	-1.627E-08	2.786E-06	5.499E-06	7.825E-06	9.555E-06	1.051E-05
6	-8.987E-06	-7.237E-06	-4.913E-06	-2.095E-06	8.789E-07	3.830E-06	6.555E-06	8.742E-06	1.023E-05	1.096E-05
7	-8.863E-06	-6.984E-06	-4.551E-06	-1.572E-06	1.644E-06	4.849E-06	7.716E-06	9.874E-06	1.115E-05	1.159E-05
8	-8.870E-06	-6.884E-06	-4.363E-06	-1.250E-06	2.218E-06	5.726E-06	8.849E-06	1.112E-05	1.226E-05	1.237E-05
9	-8.852E-06	-6.727E-06	-4.100E-06	-8.871E-07	2.750E-06	6.463E-06	9.786E-06	1.219E-05	1.328E-05	1.315E-05
10	-8.841E-06	-6.546E-06	-3.755E-06	-4.234E-07	3.321E-06	7.123E-06	1.052E-05	1.298E-05	1.408E-05	1.383E-05
11	-8.841E-06	-6.362E-06	-3.374E-06	8.119E-08	3.874E-06	7.666E-06	1.103E-05	1.347E-05	1.461E-05	1.439E-05
12	-8.913E-06	-6.273E-06	-3.104E-06	4.635E-07	4.288E-06	8.056E-06	1.137E-05	1.379E-05	1.503E-05	1.494E-05
13	-9.111E-06	-6.358E-06	-3.044E-06	6.401E-07	4.551E-06	8.372E-06	1.171E-05	1.415E-05	1.546E-05	1.547E-05
14	-9.419E-06	-6.622E-06	-3.223E-06	5.712E-07	4.620E-06	8.583E-06	1.205E-05	1.458E-05	1.598E-05	1.603E-05
15	-9.799E-06	-6.964E-06	-3.491E-06	4.055E-07	4.597E-06	8.709E-06	1.232E-05	1.499E-05	1.648E-05	1.655E-05
16	-1.023E-05	-7.308E-06	-3.727E-06	2.809E-07	4.595E-06	8.814E-06	1.252E-05	1.531E-05	1.689E-05	1.697E-05
17	-1.062E-05	-7.567E-06	-3.877E-06	2.001E-07	4.563E-06	8.815E-06	1.257E-05	1.545E-05	1.716E-05	1.731E-05
18	-1.098E-05	-7.782E-06	-4.059E-06	-2.188E-08	4.304E-06	8.556E-06	1.239E-05	1.545E-05	1.737E-05	1.771E-05
19	-1.146E-05	-8.188E-06	-4.513E-06	-5.605E-07	3.749E-06	8.086E-06	1.213E-05	1.546E-05	1.764E-05	1.817E-05
20	-1.229E-05	-8.996E-06	-5.356E-06	-1.404E-06	2.997E-06	7.533E-06	1.188E-05	1.553E-05	1.796E-05	1.867E-05
21	-1.355E-05	-1.027E-05	-6.579E-06	-2.467E-06	2.185E-06	7.046E-06	1.176E-05	1.570E-05	1.830E-05	1.914E-05
22	-1.488E-05	-1.171E-05	-7.971E-06	-3.616E-06	1.390E-06	6.659E-06	1.175E-05	1.590E-05	1.858E-05	1.948E-05
23	-1.605E-05	-1.303E-05	-9.247E-06	-4.653E-06	6.933E-07	6.348E-06	1.175E-05	1.606E-05	1.879E-05	1.975E-05
24	-1.687E-05	-1.398E-05	-1.022E-05	-5.503E-06	5.292E-08	5.988E-06	1.164E-05	1.611E-05	1.897E-05	2.005E-05
25	-1.742E-05	-1.455E-05	-1.077E-05	-6.052E-06	-4.676E-07	5.575E-06	1.141E-05	1.610E-05	1.923E-05	2.048E-05
26	-1.769E-05	-1.476E-05	-1.099E-05	-6.370E-06	-9.000E-07	5.121E-06	1.107E-05	1.603E-05	1.951E-05	2.100E-05
27	-1.769E-05	-1.463E-05	-1.087E-05	-6.455E-06	-1.244E-06	4.624E-06	1.062E-05	1.588E-05	1.982E-05	2.159E-05

Table G-7. Calculated Peak Strains at 411 Hz (“Pathfinder” PWA)

Row \ Column	21	22	23	24	25	26	27	28	29	30
1	1.015E-05	9.874E-06	8.769E-06	6.918E-06	4.500E-06	1.649E-06	-1.369E-06	-4.135E-06	-6.153E-06	-7.276E-06
2	1.011E-05	9.681E-06	8.548E-06	6.649E-06	4.097E-06	1.102E-06	-2.006E-06	-4.678E-06	-6.495E-06	-7.445E-06
3	1.014E-05	9.560E-06	8.337E-06	6.337E-06	3.652E-06	5.518E-07	-2.609E-06	-5.221E-06	-6.929E-06	-7.796E-06
4	1.026E-05	9.513E-06	8.137E-06	5.983E-06	3.167E-06	-2.480E-09	-3.179E-06	-5.766E-06	-7.456E-06	-8.327E-06
5	1.045E-05	9.554E-06	7.954E-06	5.568E-06	2.615E-06	-5.641E-07	-3.679E-06	-6.258E-06	-8.045E-06	-9.050E-06
6	1.075E-05	9.665E-06	7.780E-06	5.127E-06	2.049E-06	-1.123E-06	-4.186E-06	-6.820E-06	-8.785E-06	-9.984E-06
7	1.112E-05	9.763E-06	7.577E-06	4.682E-06	1.494E-06	-1.696E-06	-4.772E-06	-7.512E-06	-9.658E-06	-1.101E-05
8	1.155E-05	9.853E-06	7.373E-06	4.283E-06	9.788E-07	-2.299E-06	-5.472E-06	-8.341E-06	-1.060E-05	-1.199E-05
9	1.201E-05	9.987E-06	7.248E-06	3.992E-06	5.219E-07	-2.930E-06	-6.240E-06	-9.183E-06	-1.143E-05	-1.270E-05
10	1.250E-05	1.024E-05	7.276E-06	3.836E-06	1.422E-07	-3.536E-06	-6.980E-06	-9.950E-06	-1.211E-05	-1.320E-05
11	1.302E-05	1.064E-05	7.486E-06	3.844E-06	-9.415E-08	-4.005E-06	-7.575E-06	-1.058E-05	-1.269E-05	-1.366E-05
12	1.364E-05	1.121E-05	7.898E-06	4.030E-06	-1.529E-07	-4.293E-06	-8.028E-06	-1.114E-05	-1.333E-05	-1.432E-05
13	1.420E-05	1.176E-05	8.347E-06	4.311E-06	-5.222E-08	-4.395E-06	-8.350E-06	-1.166E-05	-1.406E-05	-1.518E-05
14	1.472E-05	1.224E-05	8.769E-06	4.637E-06	1.692E-07	-4.346E-06	-8.561E-06	-1.214E-05	-1.480E-05	-1.613E-05
15	1.519E-05	1.265E-05	9.151E-06	4.970E-06	4.293E-07	-4.238E-06	-8.705E-06	-1.254E-05	-1.542E-05	-1.693E-05
16	1.558E-05	1.300E-05	9.478E-06	5.276E-06	6.841E-07	-4.097E-06	-8.754E-06	-1.280E-05	-1.584E-05	-1.749E-05
17	1.597E-05	1.336E-05	9.798E-06	5.552E-06	8.939E-07	-3.960E-06	-8.709E-06	-1.287E-05	-1.600E-05	-1.775E-05
18	1.649E-05	1.387E-05	1.020E-05	5.831E-06	1.060E-06	-3.845E-06	-8.600E-06	-1.278E-05	-1.593E-05	-1.776E-05
19	1.708E-05	1.442E-05	1.062E-05	6.088E-06	1.193E-06	-3.739E-06	-8.429E-06	-1.251E-05	-1.561E-05	-1.744E-05
20	1.769E-05	1.501E-05	1.109E-05	6.378E-06	1.362E-06	-3.597E-06	-8.196E-06	-1.213E-05	-1.512E-05	-1.692E-05
21	1.824E-05	1.558E-05	1.161E-05	6.759E-06	1.625E-06	-3.392E-06	-7.952E-06	-1.177E-05	-1.465E-05	-1.638E-05
22	1.864E-05	1.605E-05	1.211E-05	7.222E-06	2.031E-06	-3.051E-06	-7.651E-06	-1.147E-05	-1.434E-05	-1.604E-05
23	1.896E-05	1.646E-05	1.258E-05	7.724E-06	2.512E-06	-2.638E-06	-7.342E-06	-1.126E-05	-1.420E-05	-1.592E-05
24	1.932E-05	1.687E-05	1.302E-05	8.208E-06	2.984E-06	-2.235E-06	-7.068E-06	-1.112E-05	-1.415E-05	-1.592E-05
25	1.980E-05	1.733E-05	1.342E-05	8.585E-06	3.317E-06	-1.979E-06	-6.902E-06	-1.097E-05	-1.400E-05	-1.580E-05
26	2.036E-05	1.781E-05	1.379E-05	8.894E-06	3.571E-06	-1.805E-06	-6.807E-06	-1.085E-05	-1.383E-05	-1.566E-05
27	2.100E-05	1.831E-05	1.411E-05	9.135E-06	3.747E-06	-1.714E-06	-6.782E-06	-1.075E-05	-1.364E-05	-1.550E-05

Table G-8. Calculated Peak Strains at 411 Hz (“Pathfinder” PWA)

Row \ Column	31	32	33	34	35	36	37	38	39
1	-7.401E-06	-6.000E-06	-4.444E-06	-2.313E-06	-1.826E-07	1.948E-06	4.079E-06	6.210E-06	8.341E-06
2	-7.512E-06	-6.236E-06	-4.781E-06	-2.810E-06	-8.399E-07	1.131E-06	3.101E-06	5.072E-06	7.042E-06
3	-7.837E-06	-6.605E-06	-5.174E-06	-3.242E-06	-1.310E-06	6.213E-07	2.553E-06	4.485E-06	6.417E-06
4	-8.376E-06	-7.107E-06	-5.624E-06	-3.609E-06	-1.594E-06	4.203E-07	2.435E-06	4.450E-06	6.465E-06
5	-9.189E-06	-7.796E-06	-6.182E-06	-3.920E-06	-1.657E-06	6.047E-07	2.867E-06	5.129E-06	7.392E-06
6	-1.019E-05	-8.578E-06	-6.747E-06	-4.146E-06	-1.546E-06	1.054E-06	3.655E-06	6.255E-06	8.855E-06
7	-1.119E-05	-9.315E-06	-7.221E-06	-4.307E-06	-1.394E-06	1.519E-06	4.433E-06	7.346E-06	1.026E-05
8	-1.201E-05	-9.921E-06	-7.585E-06	-4.494E-06	-1.403E-06	1.688E-06	4.779E-06	7.869E-06	1.096E-05
9	-1.252E-05	-1.037E-05	-7.893E-06	-4.795E-06	-1.697E-06	1.401E-06	4.499E-06	7.597E-06	1.069E-05
10	-1.287E-05	-1.075E-05	-8.203E-06	-5.123E-06	-2.044E-06	1.035E-06	4.114E-06	7.193E-06	1.027E-05
11	-1.328E-05	-1.120E-05	-8.570E-06	-5.386E-06	-2.202E-06	9.818E-07	4.166E-06	7.350E-06	1.053E-05
12	-1.399E-05	-1.178E-05	-8.989E-06	-5.491E-06	-1.994E-06	1.503E-06	5.001E-06	8.498E-06	1.200E-05
13	-1.491E-05	-1.241E-05	-9.382E-06	-5.458E-06	-1.535E-06	2.389E-06	6.313E-06	1.024E-05	1.416E-05
14	-1.591E-05	-1.307E-05	-9.791E-06	-5.464E-06	-1.139E-06	3.187E-06	7.513E-06	1.184E-05	1.616E-05
15	-1.675E-05	-1.362E-05	-1.015E-05	-5.525E-06	-9.057E-07	3.714E-06	8.334E-06	1.295E-05	1.757E-05
16	-1.737E-05	-1.407E-05	-1.042E-05	-5.546E-06	-6.713E-07	4.203E-06	9.079E-06	1.395E-05	1.883E-05
17	-1.775E-05	-1.438E-05	-1.060E-05	-5.487E-06	-3.742E-07	4.739E-06	9.853E-06	1.497E-05	2.008E-05
18	-1.789E-05	-1.454E-05	-1.067E-05	-5.361E-06	-4.980E-08	5.261E-06	1.057E-05	1.588E-05	2.120E-05
19	-1.768E-05	-1.444E-05	-1.063E-05	-5.310E-06	1.161E-08	5.333E-06	1.066E-05	1.598E-05	2.130E-05
20	-1.721E-05	-1.421E-05	-1.059E-05	-5.483E-06	-3.749E-07	4.733E-06	9.842E-06	1.495E-05	2.006E-05
21	-1.667E-05	-1.392E-05	-1.054E-05	-5.765E-06	-9.869E-07	3.791E-06	8.570E-06	1.335E-05	1.813E-05
22	-1.631E-05	-1.372E-05	-1.050E-05	-5.960E-06	-1.421E-06	3.119E-06	7.658E-06	1.220E-05	1.674E-05
23	-1.618E-05	-1.365E-05	-1.048E-05	-6.029E-06	-1.583E-06	2.862E-06	7.309E-06	1.175E-05	1.620E-05
24	-1.622E-05	-1.368E-05	-1.049E-05	-6.036E-06	-1.579E-06	2.877E-06	7.334E-06	1.179E-05	1.625E-05
25	-1.618E-05	-1.367E-05	-1.059E-05	-6.205E-06	-1.823E-06	2.558E-06	6.940E-06	1.132E-05	1.570E-05
26	-1.614E-05	-1.369E-05	-1.074E-05	-6.443E-06	-2.147E-06	2.148E-06	6.444E-06	1.074E-05	1.503E-05
27	-1.612E-05	-1.372E-05	-1.095E-05	-6.750E-06	-2.552E-06	1.646E-06	5.845E-06	1.004E-05	1.424E-05

Appendix H. Weibull Plots Demonstrating Data Fit (Z-axis Data)

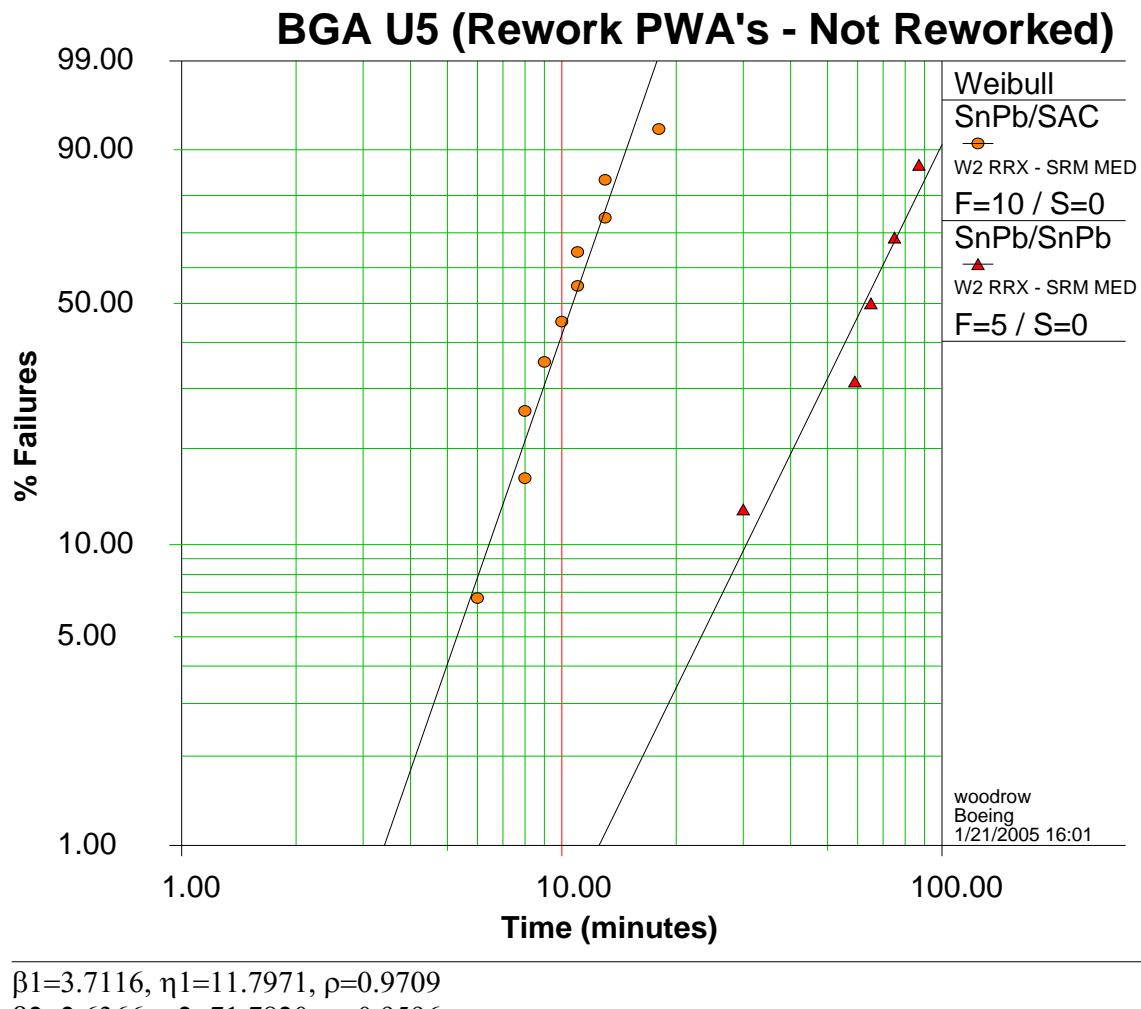


Figure H-1. Weibull Plot of BGA U5 Data (SnPb Solder Paste/SAC Ball Alloy)

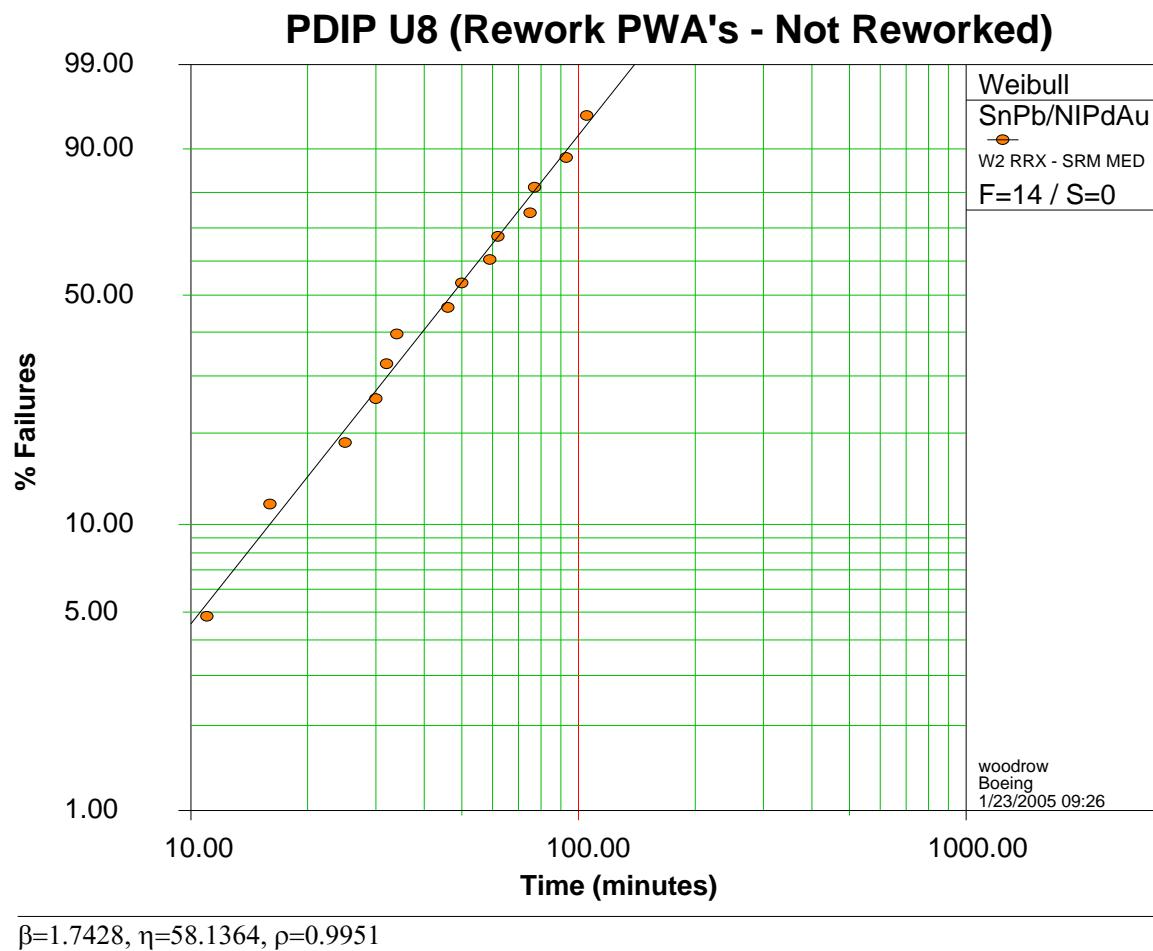
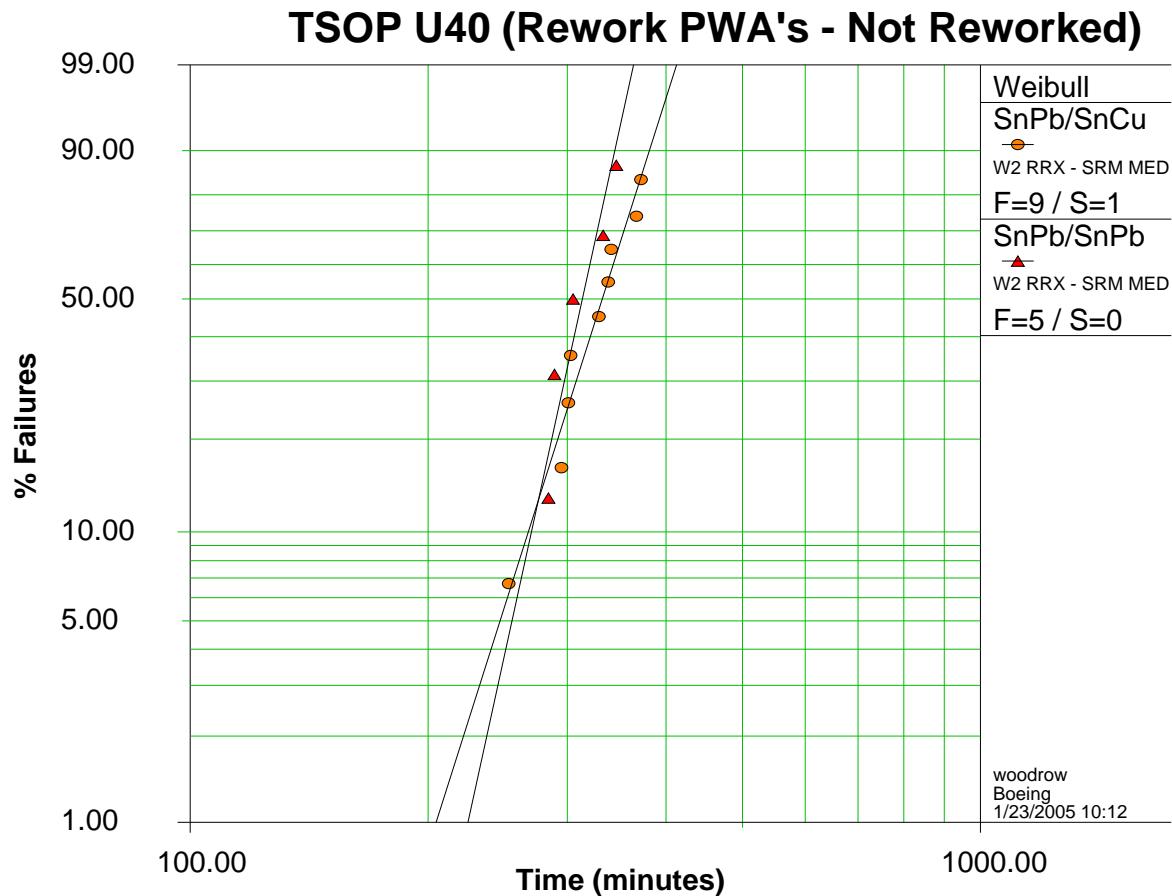


Figure H-2. Weibull Plot of PDIP U8 Data (SnPb Solder Paste/NiPdAu Component Finish)



$$\begin{aligned}\beta_1 &= 8.7447, \eta_1 = 346.4442, \rho = 0.9827 \\ \beta_2 &= 12.6901, \eta_2 = 322.7158, \rho = 0.9449\end{aligned}$$

Figure H-3. Weibull Plot of TSOP U40 Data (SnPb Solder Paste/SnCu Component Finish)

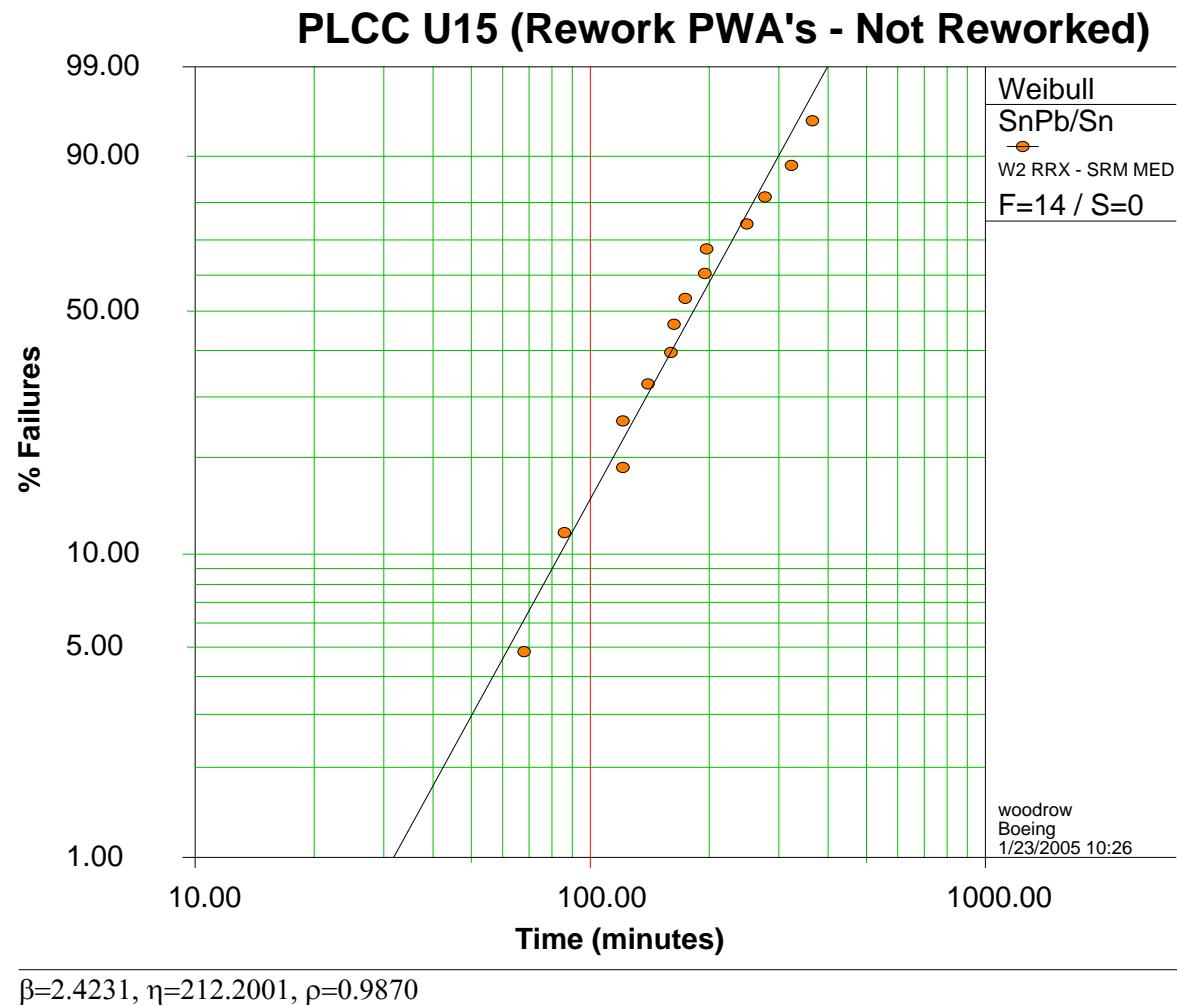


Figure H-4. Weibull Plot of PLCC U15 Data (SnPb Solder Paste/Sn Component Finish)

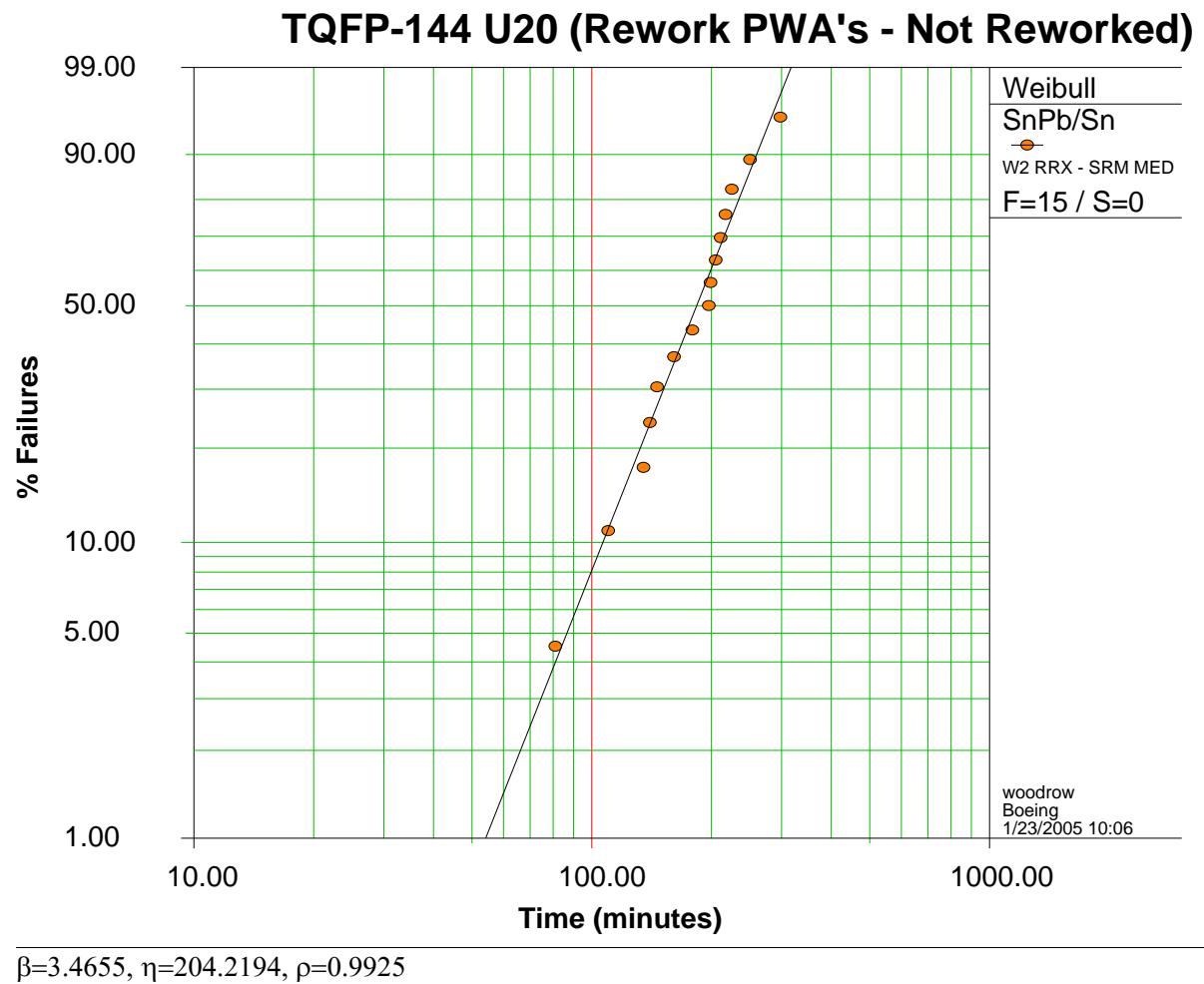


Figure H-5. Weibull Plot of TQFP-144 U20 Data (SnPb Solder Paste/Sn Component Finish)

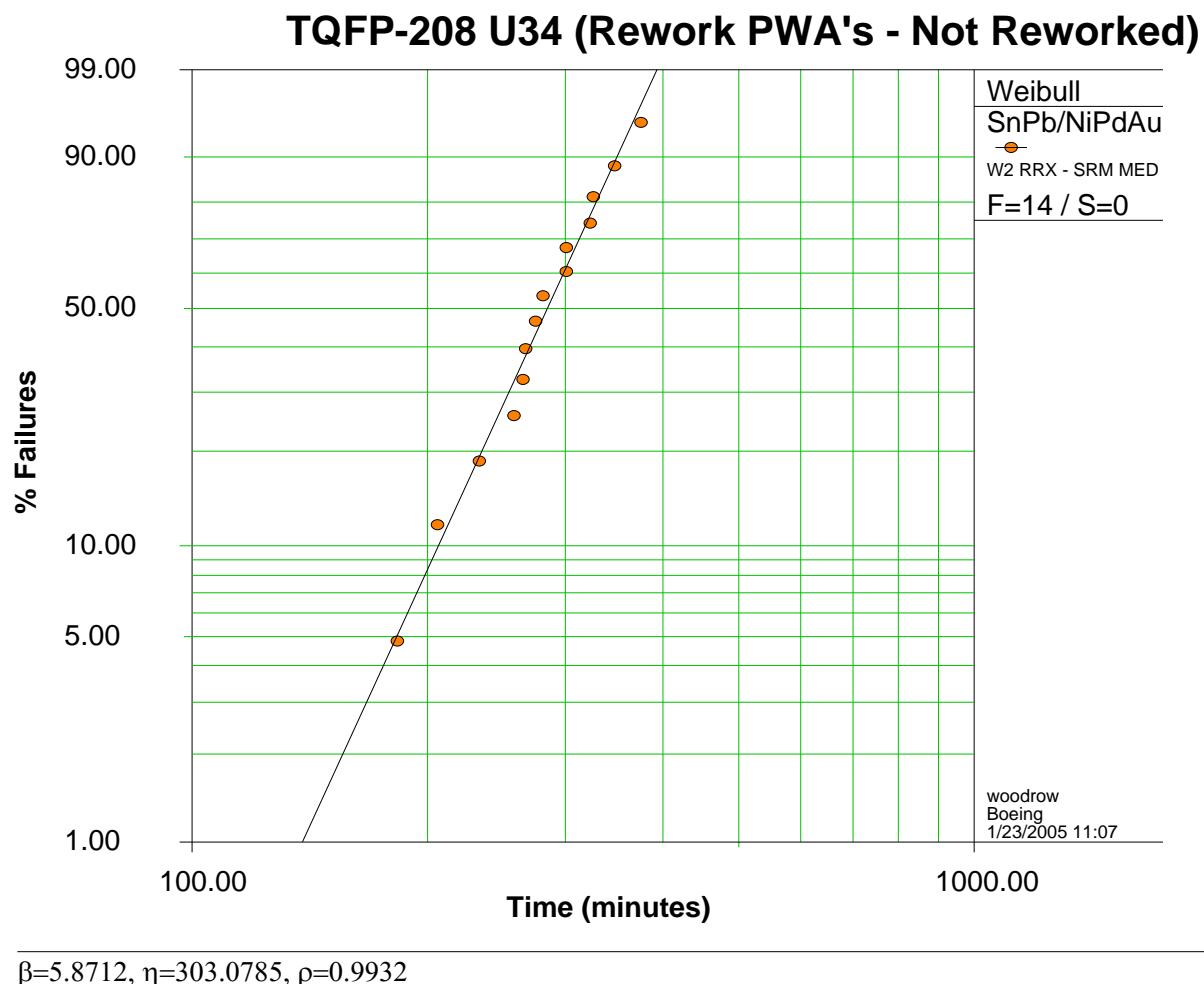
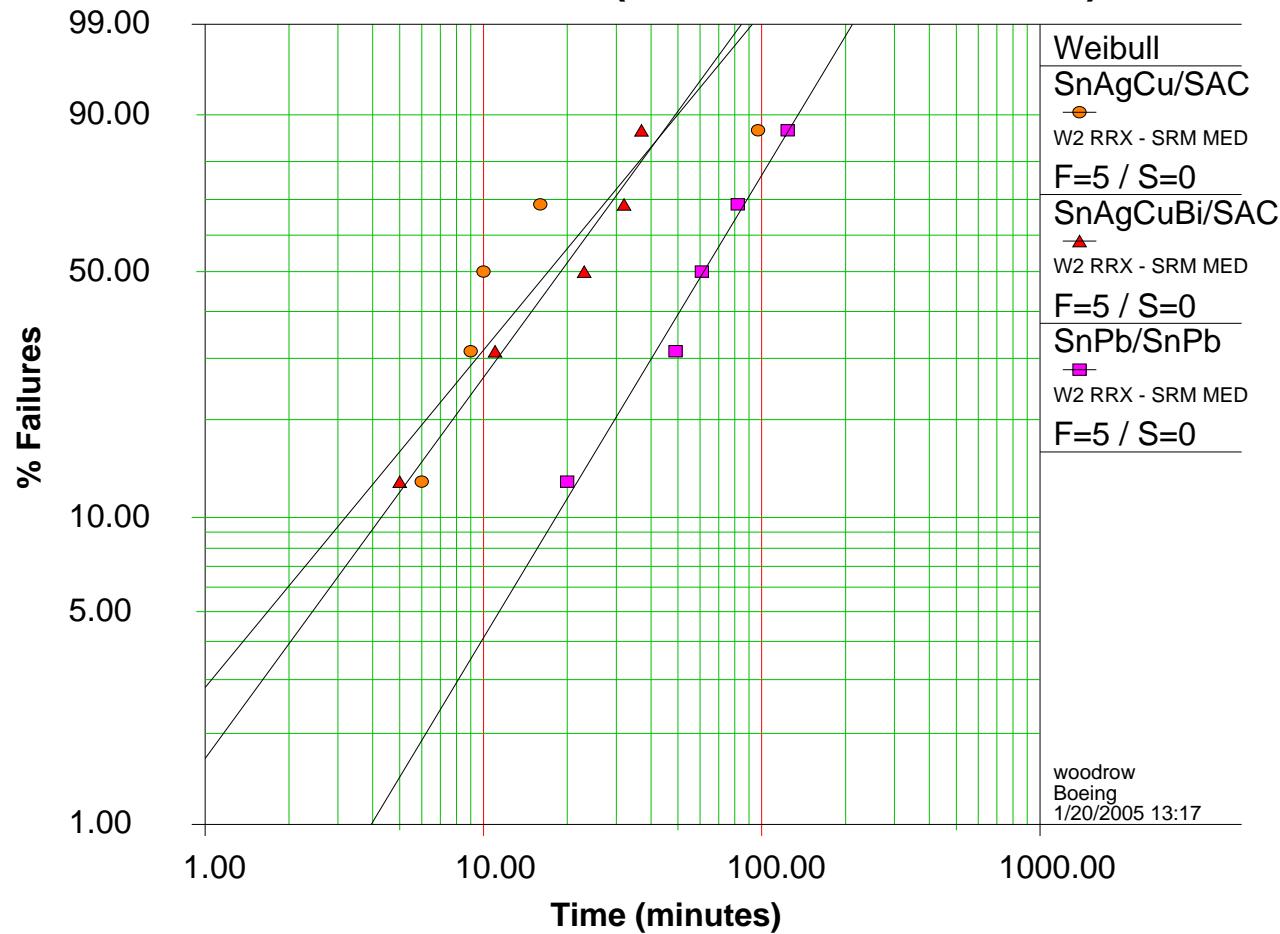


Figure H-6. Weibull Plot of TQFP-208 U34 Data (SnPb Solder Paste/NiPdAu Component Finish)

Appendix I. Weibull Plots (Z-axis Data)

BGA-225 U4 (Manufactured PWA's)

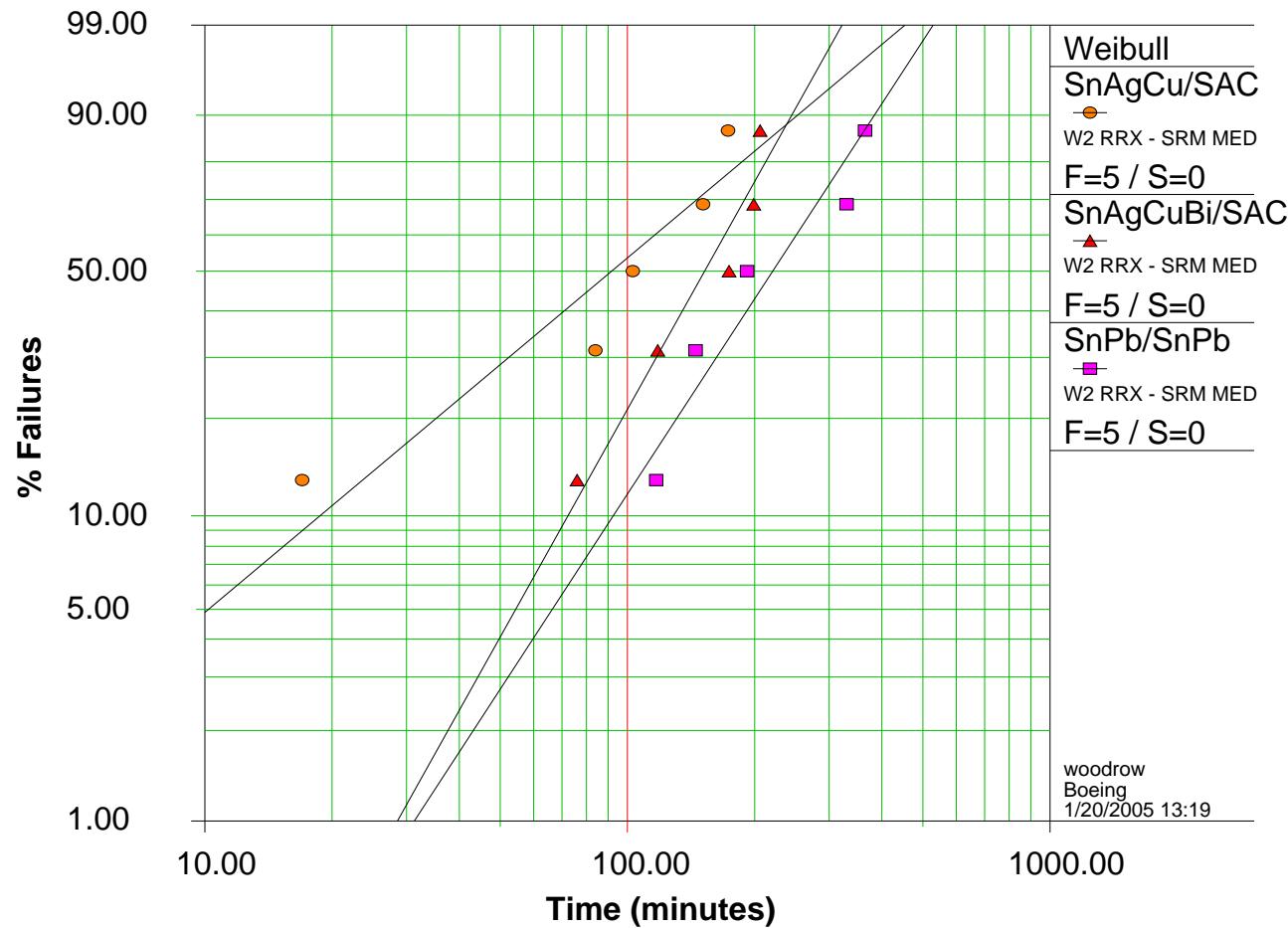


$\beta_1=1.1215$, $\eta_1=23.7082$, $\rho=0.8501$

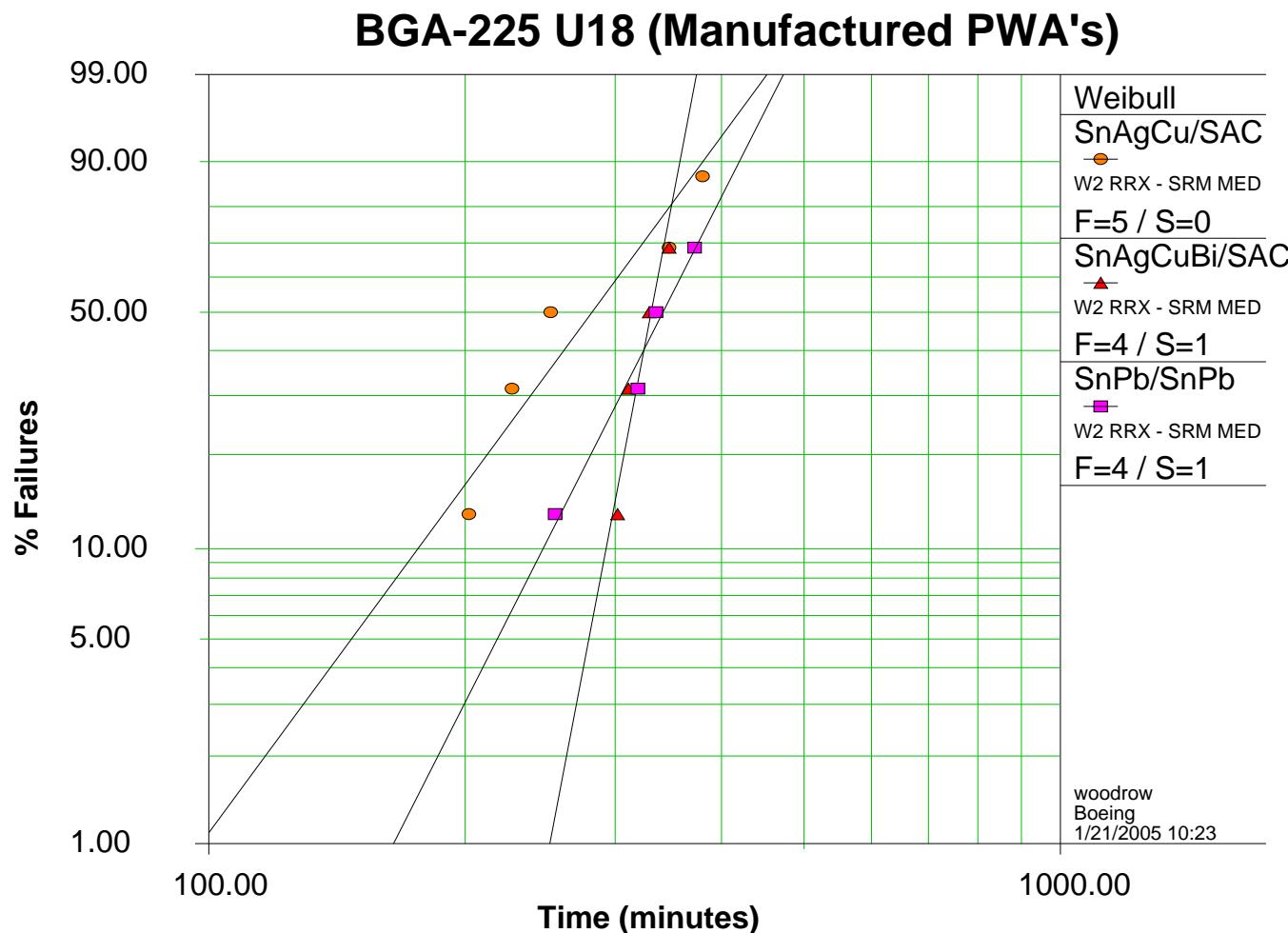
$\beta_2=1.2672$, $\eta_2=25.3196$, $\rho=0.9831$

$\beta_3=1.5387$, $\eta_3=78.5989$, $\rho=0.9901$

BGA-225 U6 (Manufactured PWA's)

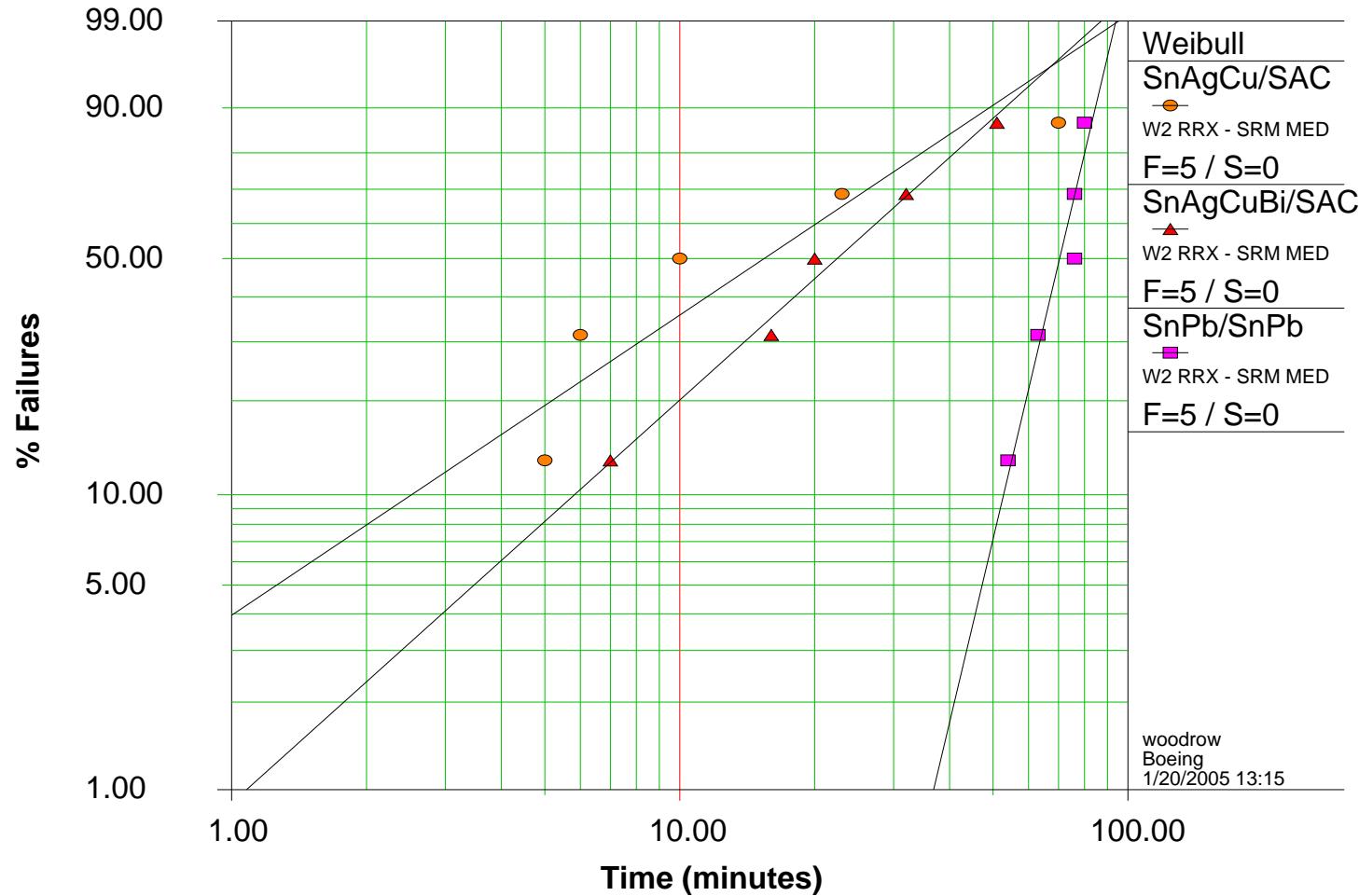


$\beta_1=1.1853, \eta_1=125.0021, \rho=0.9428$
 $\beta_2=2.5290, \eta_2=176.0175, \rho=0.9708$
 $\beta_3=2.1674, \eta_3=261.3190, \rho=0.9603$



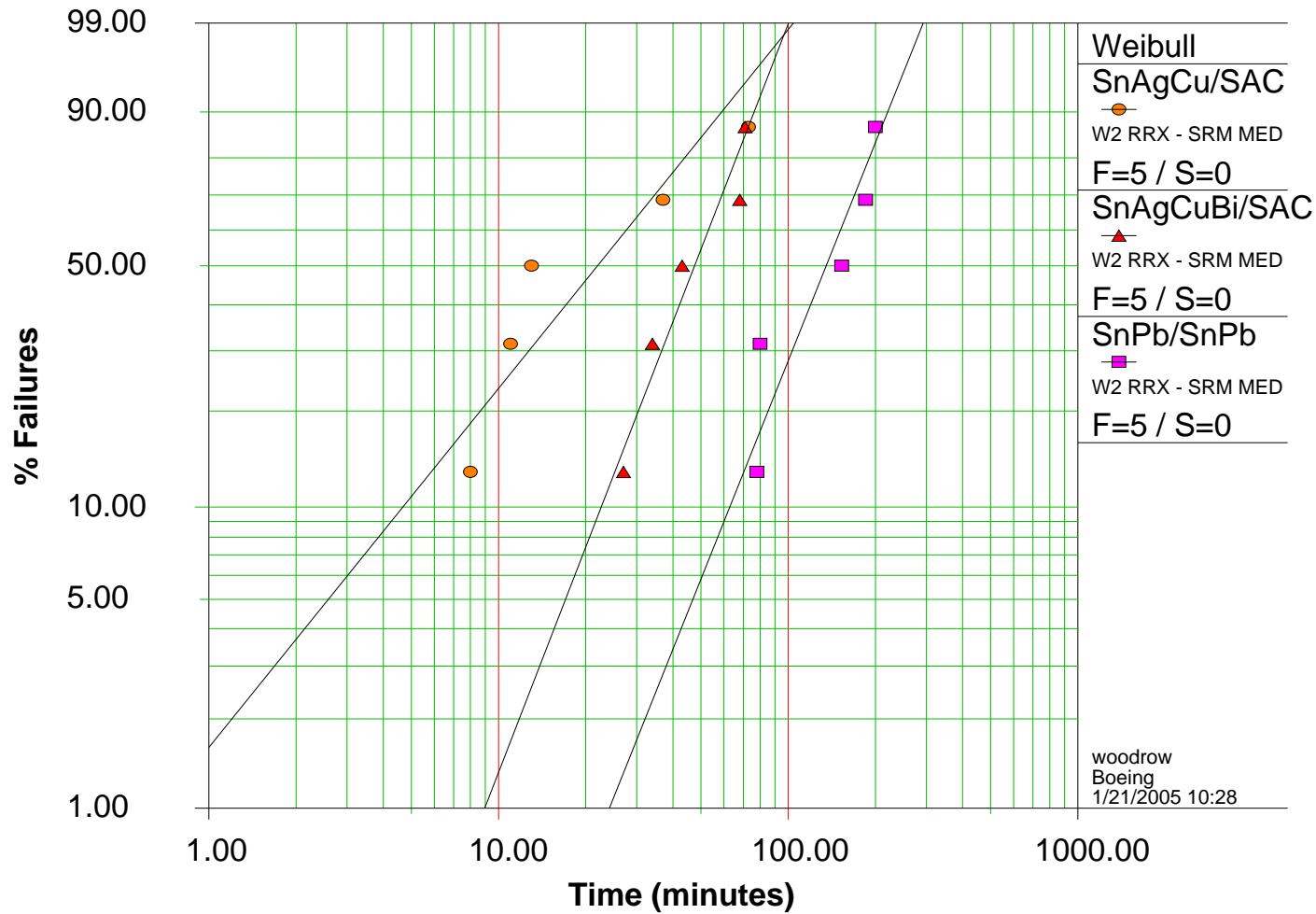
$\beta_1=4.0029, \eta_1=308.9435, \rho=0.9509$
 $\beta_2=15.4546, \eta_2=338.7303, \rho=0.9593$
 $\beta_3=5.8084, \eta_3=363.7163, \rho=0.9870$

BGA-225 U43 (Manufactured PWA's)



$\beta_1=1.0390, \eta_1=21.9854, \rho=0.9201$
 $\beta_2=1.3948, \eta_2=29.2123, \rho=0.9943$
 $\beta_3=6.5406, \eta_3=74.4579, \rho=0.9628$

BGA-225 U55 (Manufactured PWA's)

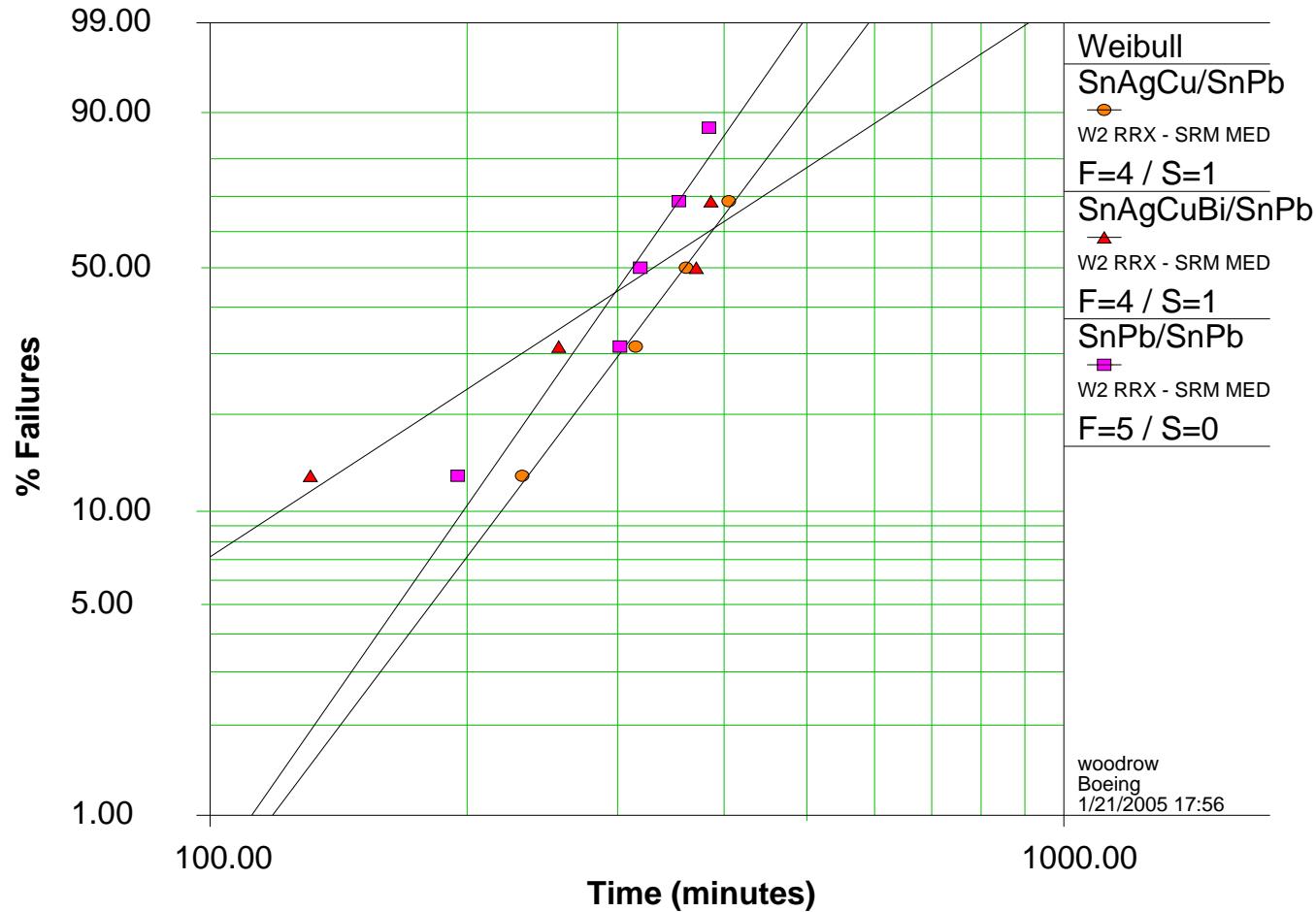


$\beta_1=1.2160, \eta_1=29.7476, \rho=0.9219$

$\beta_2=2.5366, \eta_2=54.9704, \rho=0.9657$

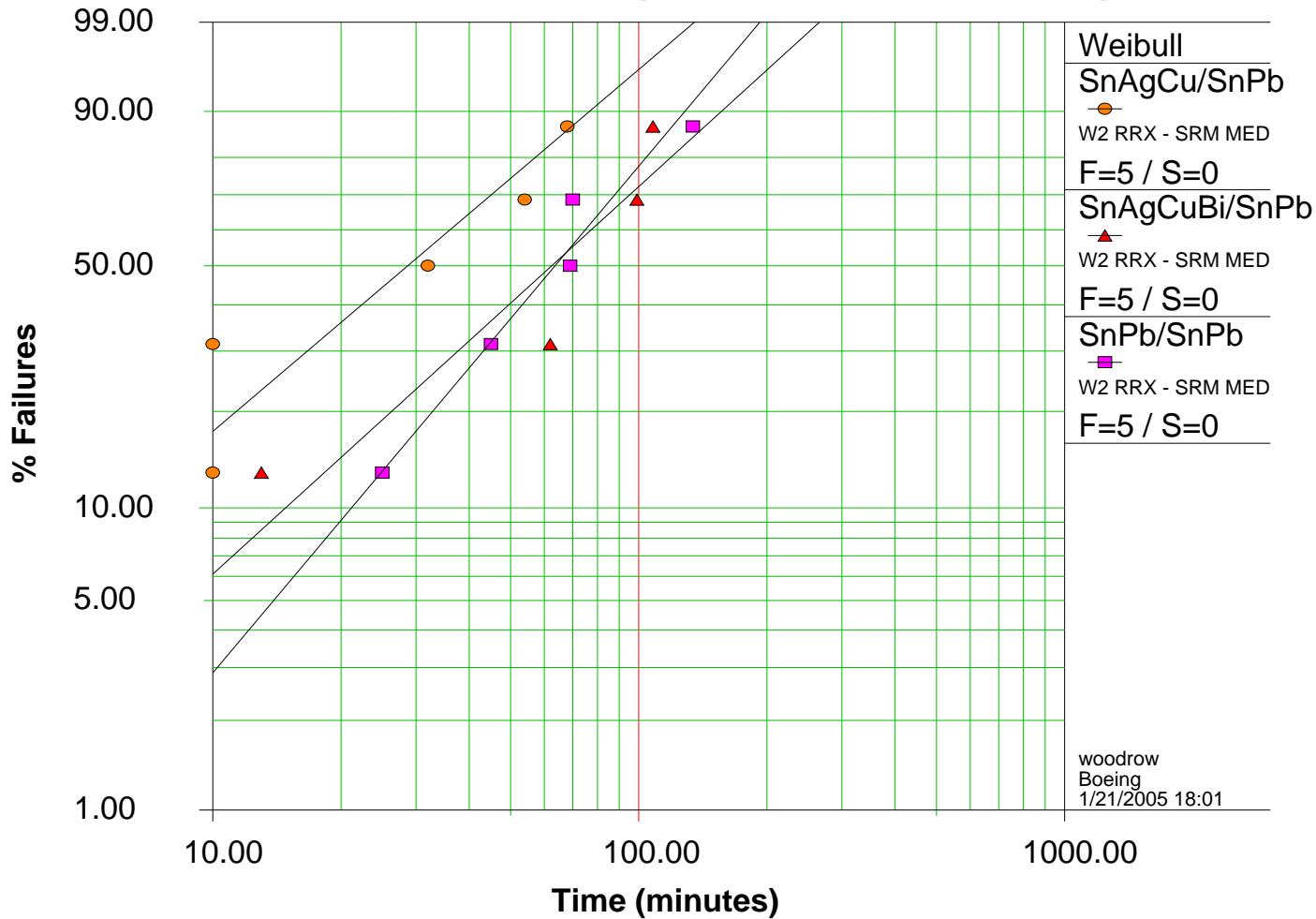
$\beta_3=2.4547, \eta_3=157.2296, \rho=0.9277$

BGA-225 U2 (Manufactured PWA's)

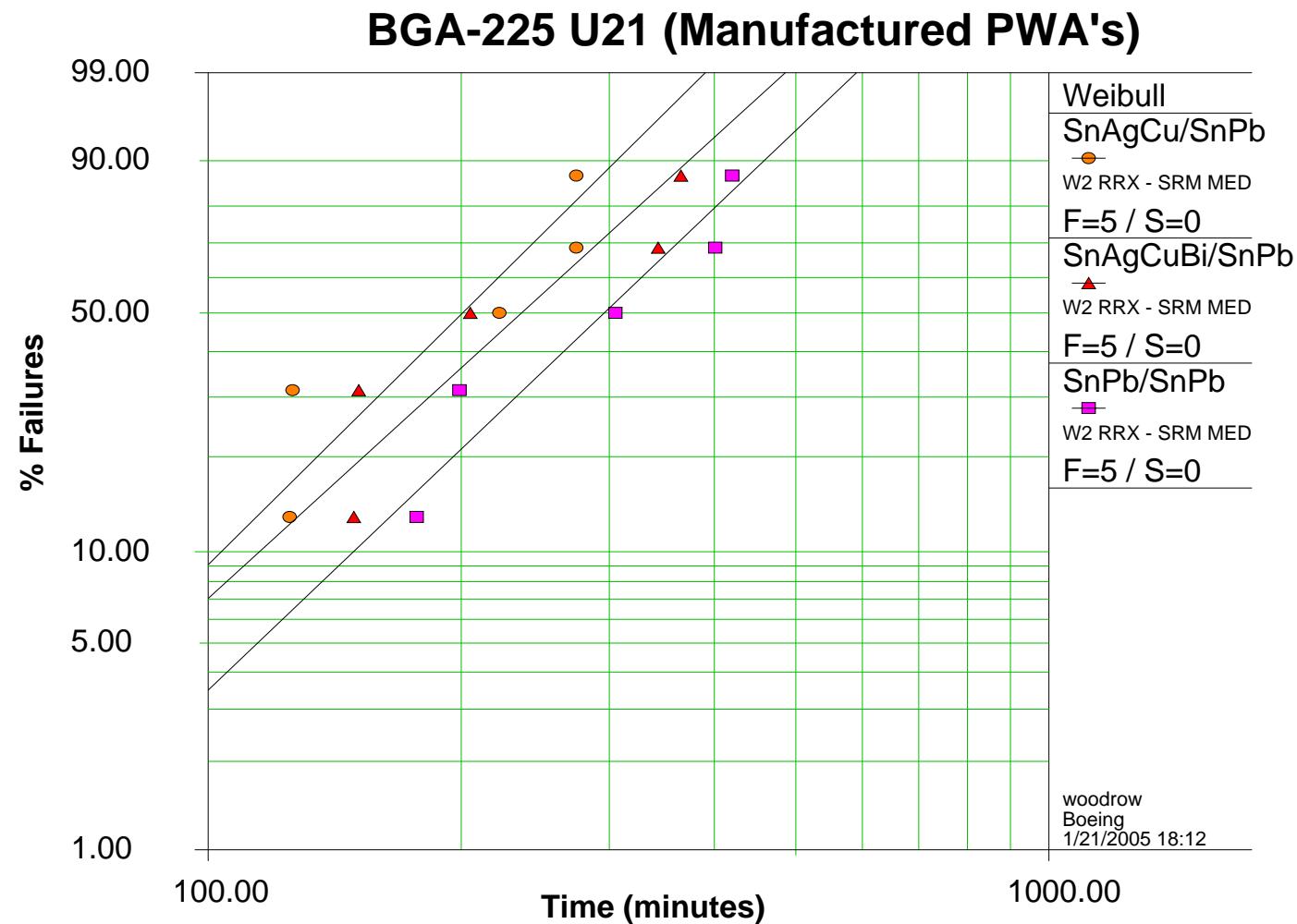


$\beta_1=3.8087, \eta_1=395.9132, \rho=0.9963$
 $\beta_2=1.8695, \eta_2=402.3064, \rho=0.9752$
 $\beta_3=4.1228, \eta_3=341.3377, \rho=0.9574$

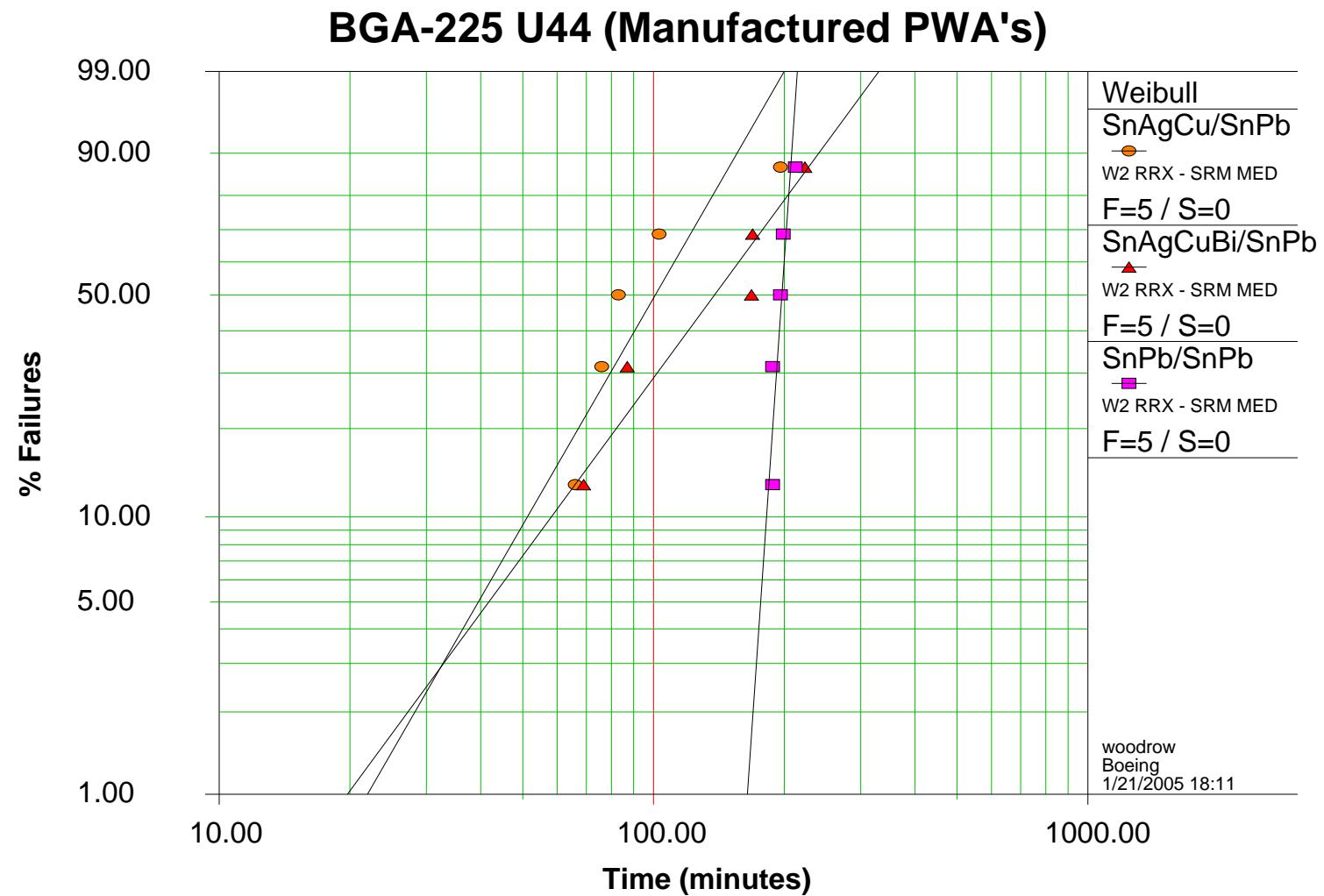
BGA-225 U5 (Manufactured PWA's)



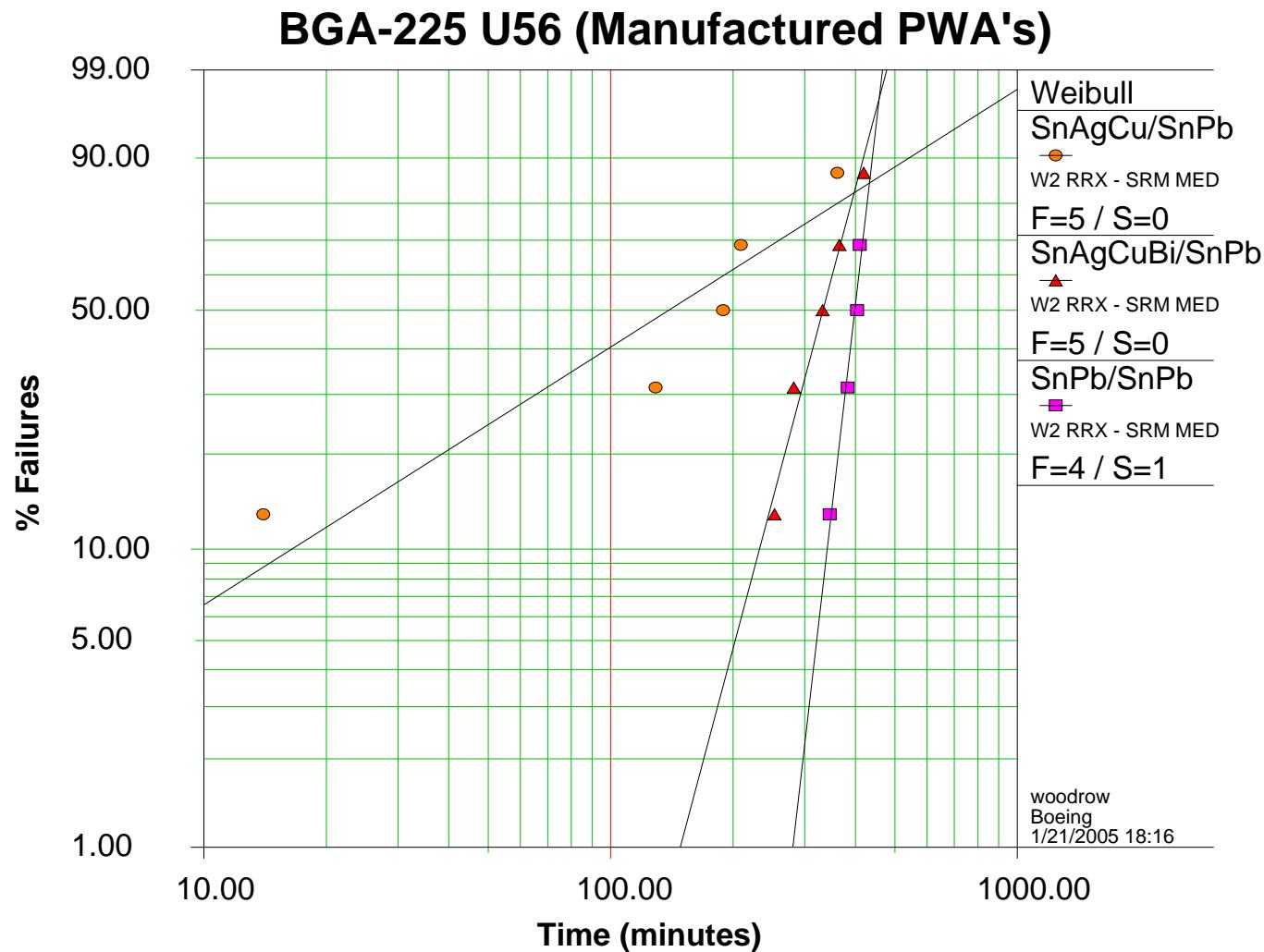
$\beta_1=1.2217, \eta_1=38.7833, \rho=0.9325$
 $\beta_2=1.3083, \eta_2=82.7814, \rho=0.9262$
 $\beta_3=1.7107, \eta_3=78.9156, \rho=0.9798$



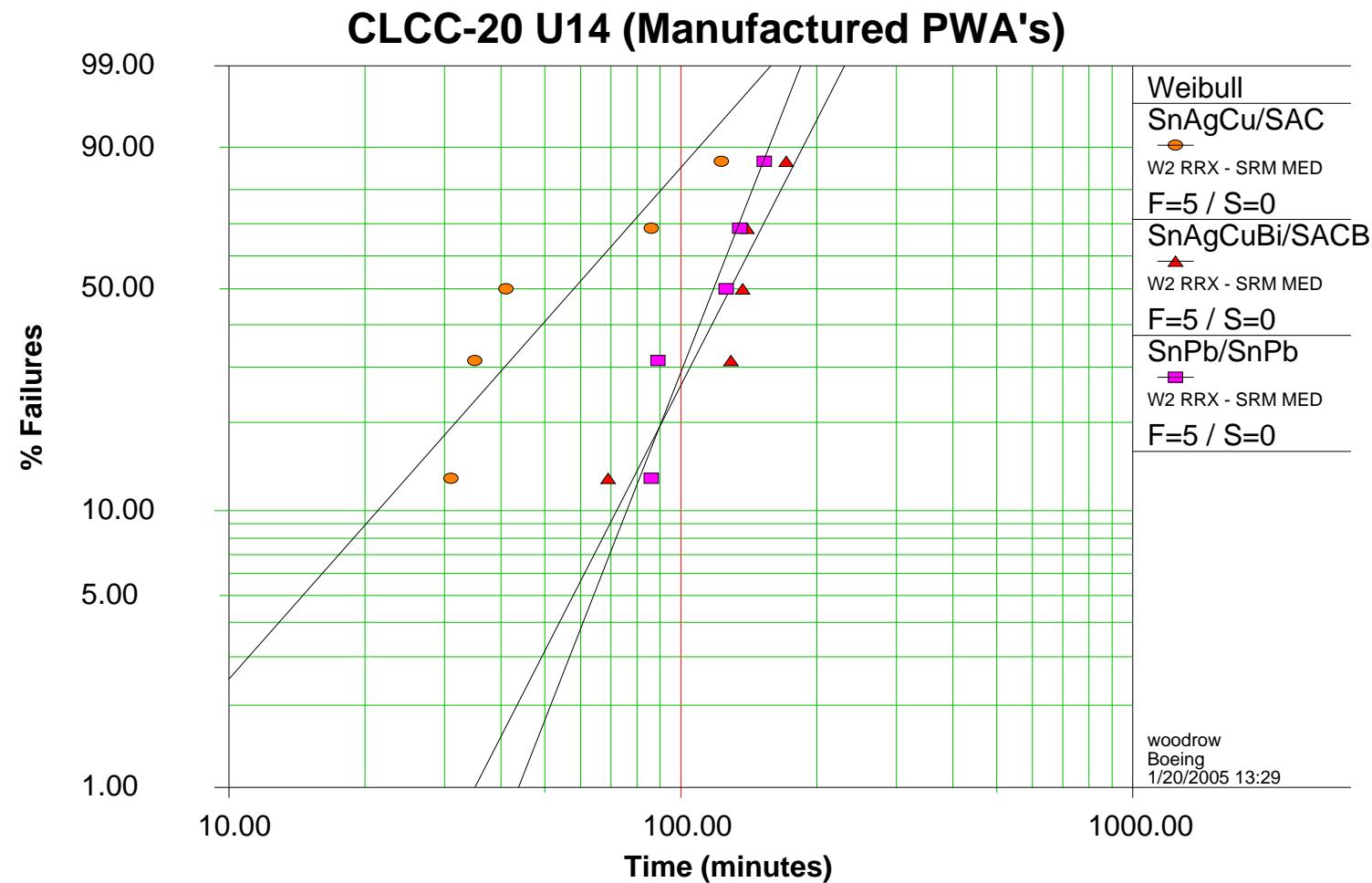
$\beta_1=2.8489, \eta_1=228.4109, \rho=0.9149$
 $\beta_2=2.6225, \eta_2=271.4298, \rho=0.9154$
 $\beta_3=2.7405, \eta_3=338.3428, \rho=0.9575$



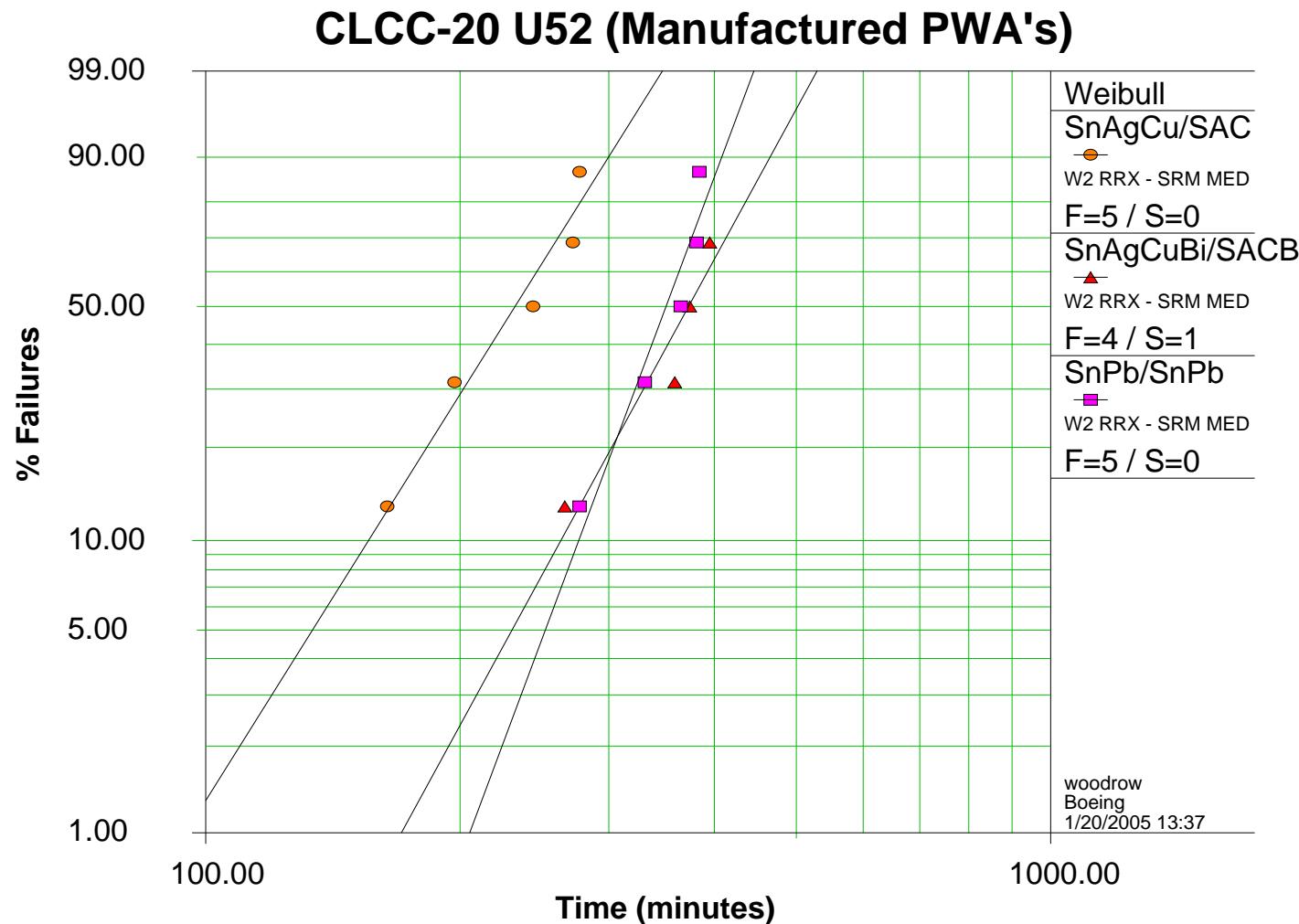
$\beta_1=2.7728, \eta_1=115.3061, \rho=0.8770$
 $\beta_2=2.1747, \eta_2=163.7131, \rho=0.9613$
 $\beta_3=23.1614, \eta_3=200.6152, \rho=0.9045$



$\beta_1=0.8824, \eta_1=210.8439, \rho=0.9348$
 $\beta_2=5.2414, \eta_2=356.8689, \rho=0.9871$
 $\beta_3=12.0741, \eta_3=411.0352, \rho=0.9839$



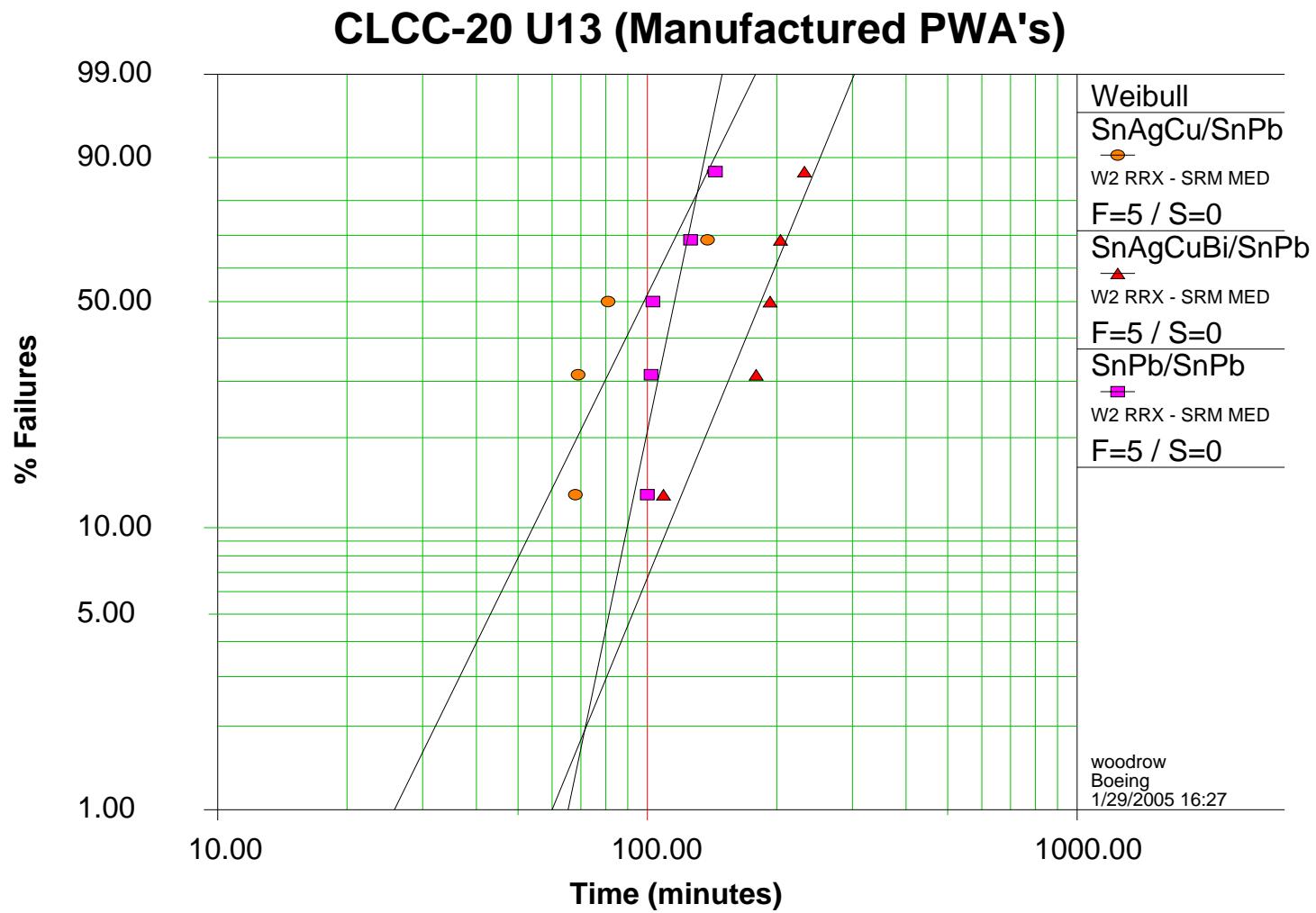
$\beta_1=1.8856, \eta_1=70.4168, \rho=0.9103$
 $\beta_2=3.2502, \eta_2=144.1121, \rho=0.9296$
 $\beta_3=4.2589, \eta_3=128.8111, \rho=0.9467$



$\beta_1=4.7142, \eta_1=251.1932, \rho=0.9777$

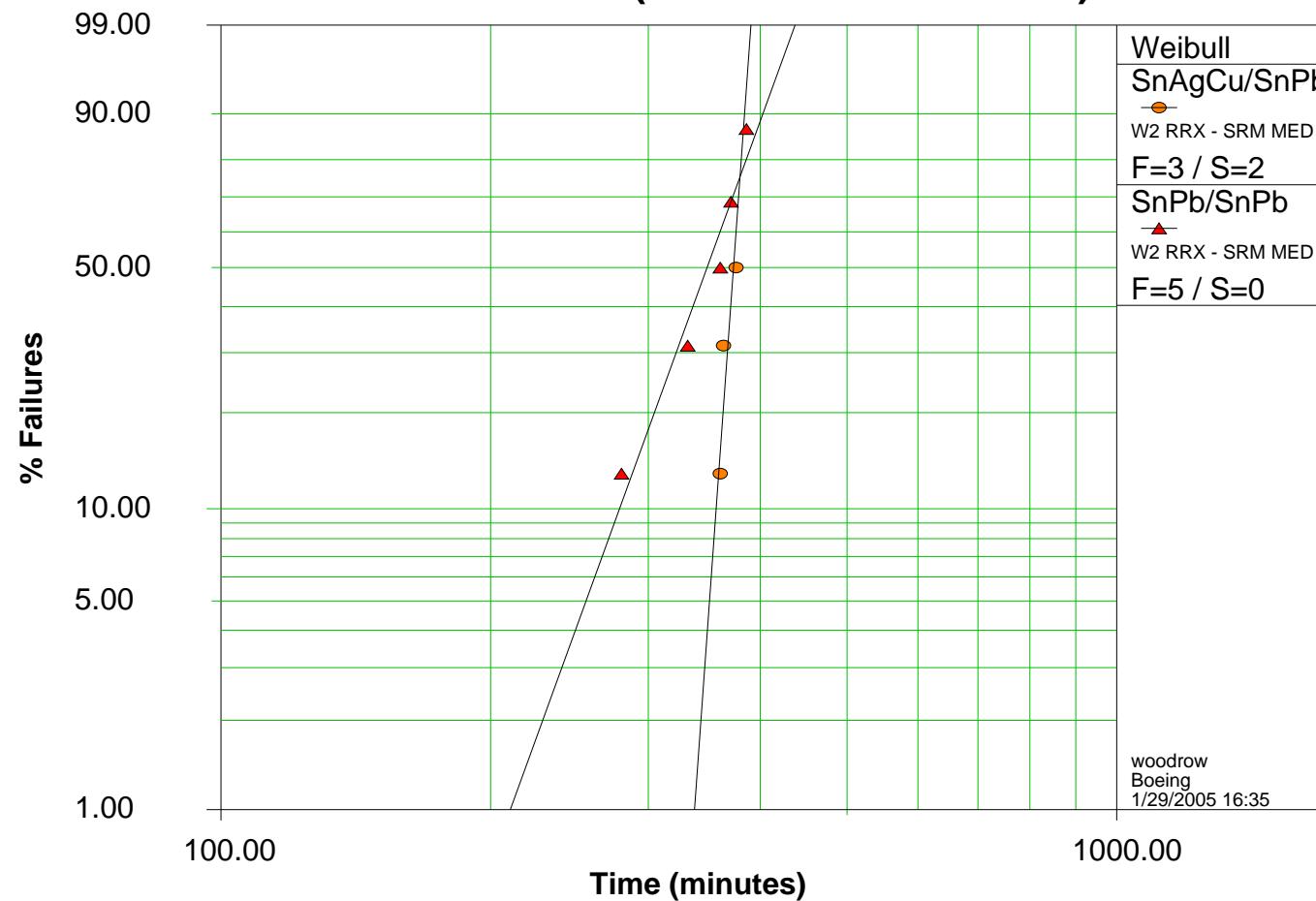
$\beta_2=5.4098, \eta_2=399.0360, \rho=0.9530$

$\beta_3=7.9147, \eta_3=367.2217, \rho=0.9626$



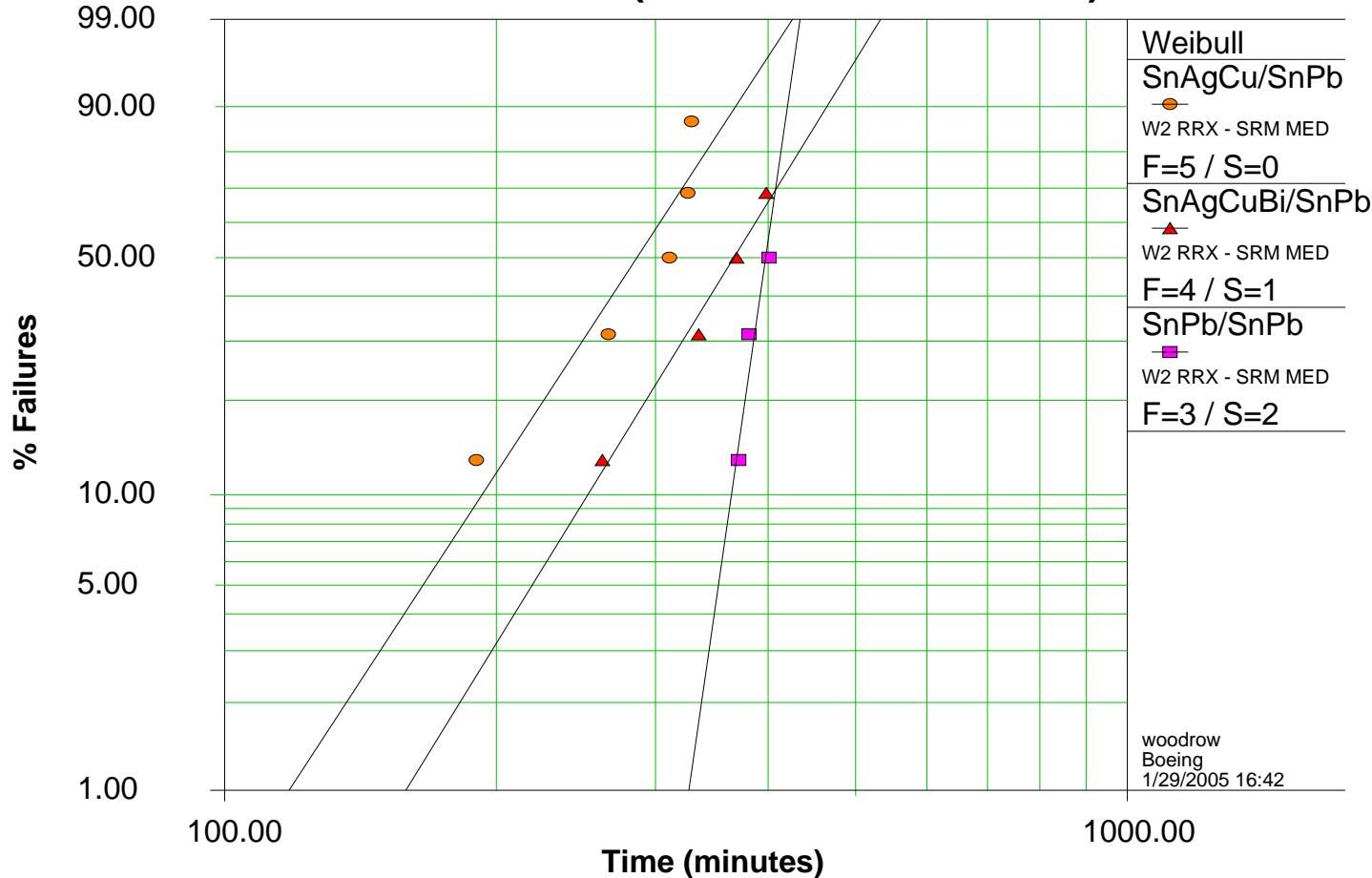
$\beta_1=3.1672, \eta_1=110.2495, \rho=0.8880$
 $\beta_2=3.7810, \eta_2=202.5909, \rho=0.9484$
 $\beta_3=7.4255, \eta_3=121.5534, \rho=0.8661$

CLCC-20 U46 (Manufactured PWA's)

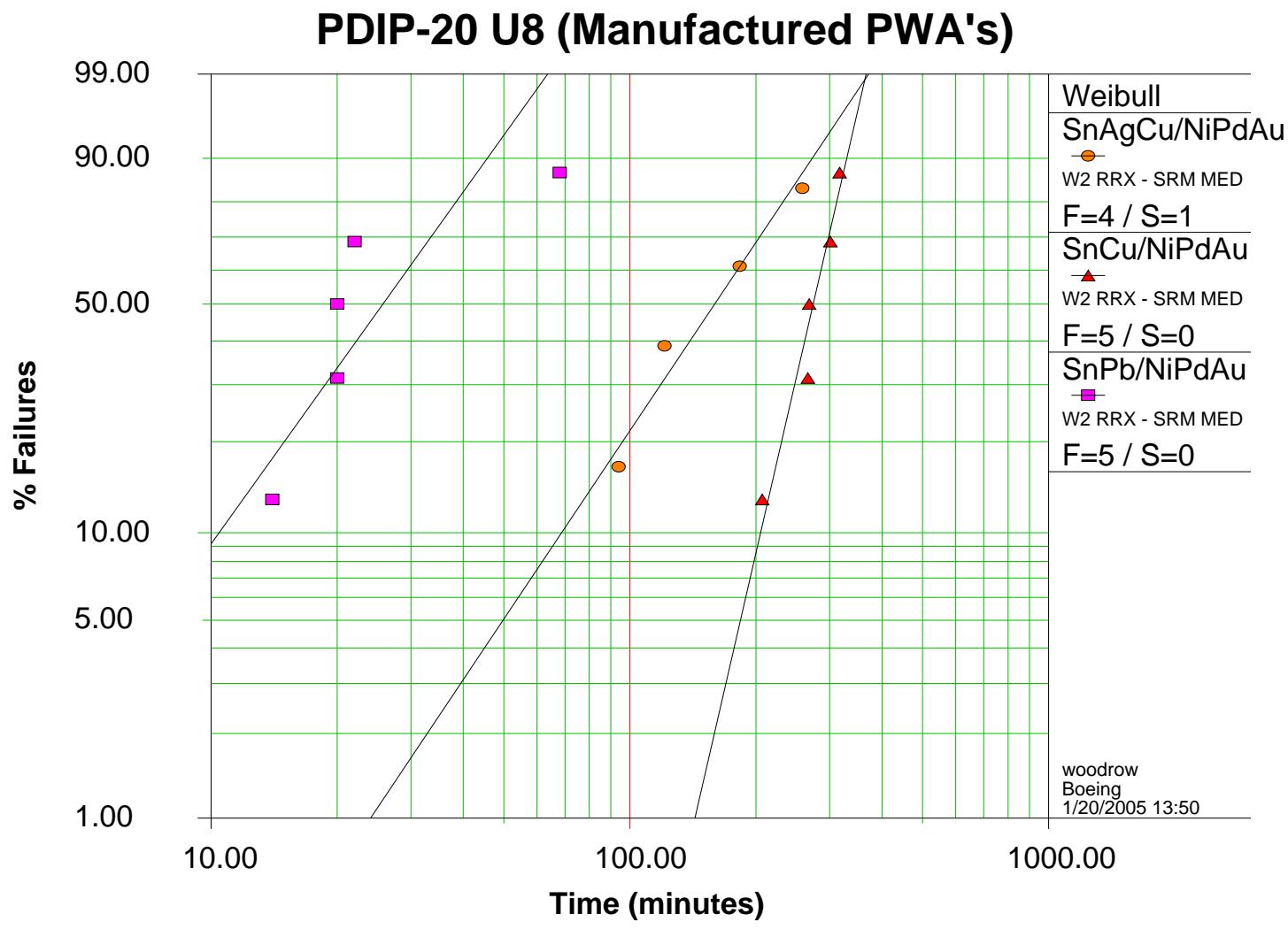


$$\begin{aligned}\beta_1 &= 42.3296, \eta_1 = 376.6602, \rho = 0.8921 \\ \beta_2 &= 8.3680, \eta_2 = 364.6278, \rho = 0.9745\end{aligned}$$

CLCC-20 U53 (Manufactured PWA's)



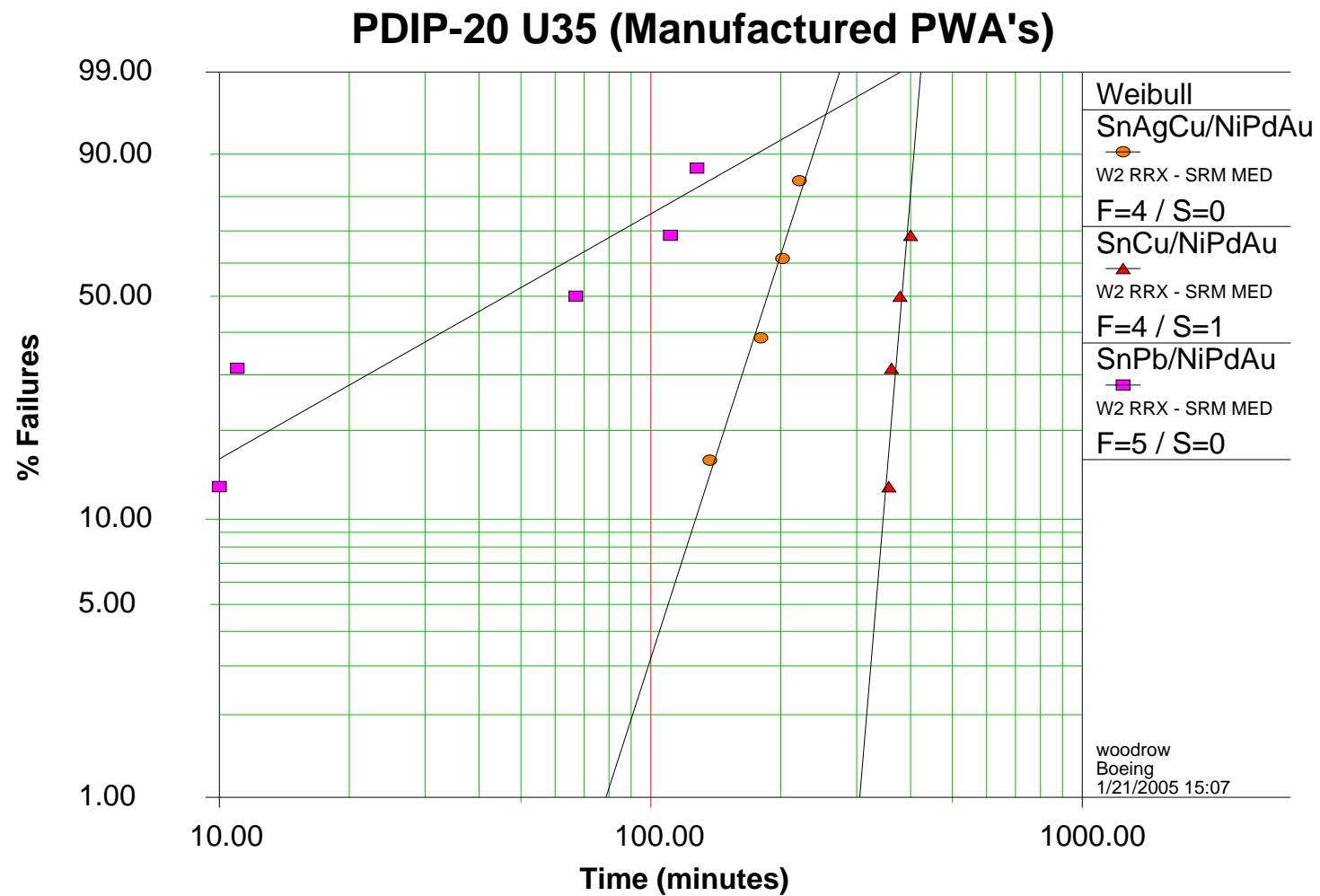
$$\begin{aligned}
 \beta_1 &= 4.7700, \eta_1 = 309.0944, \rho = 0.9438 \\
 \beta_2 &= 5.0593, \eta_2 = 394.1167, \rho = 0.9916 \\
 \beta_3 &= 21.6529, \eta_3 = 404.2696, \rho = 0.9495
 \end{aligned}$$



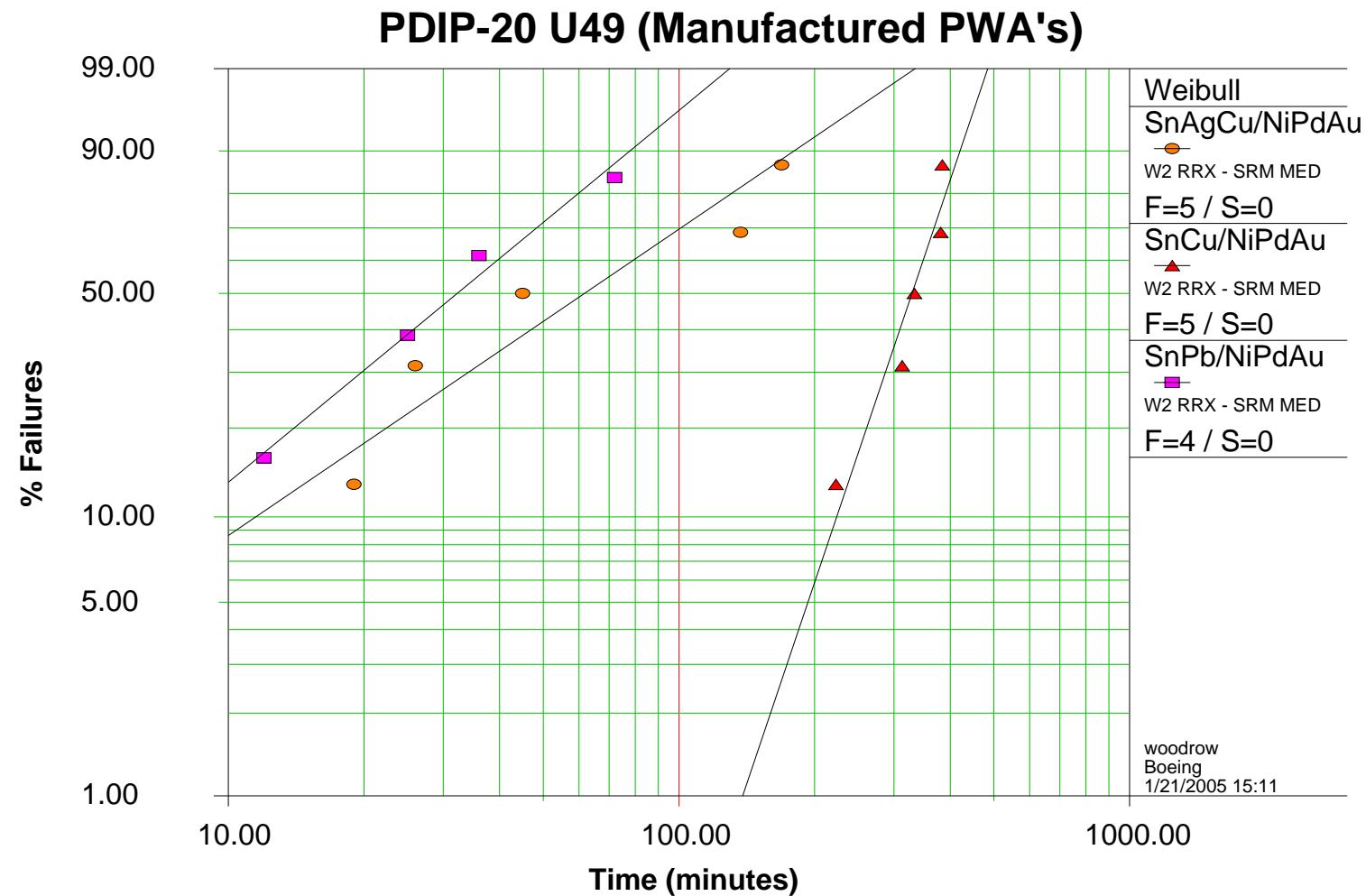
$\beta_1=2.2372$, $\eta_1=187.9656$, $\rho=0.9805$

$\beta_2=6.5059$, $\eta_2=290.0795$, $\rho=0.9703$

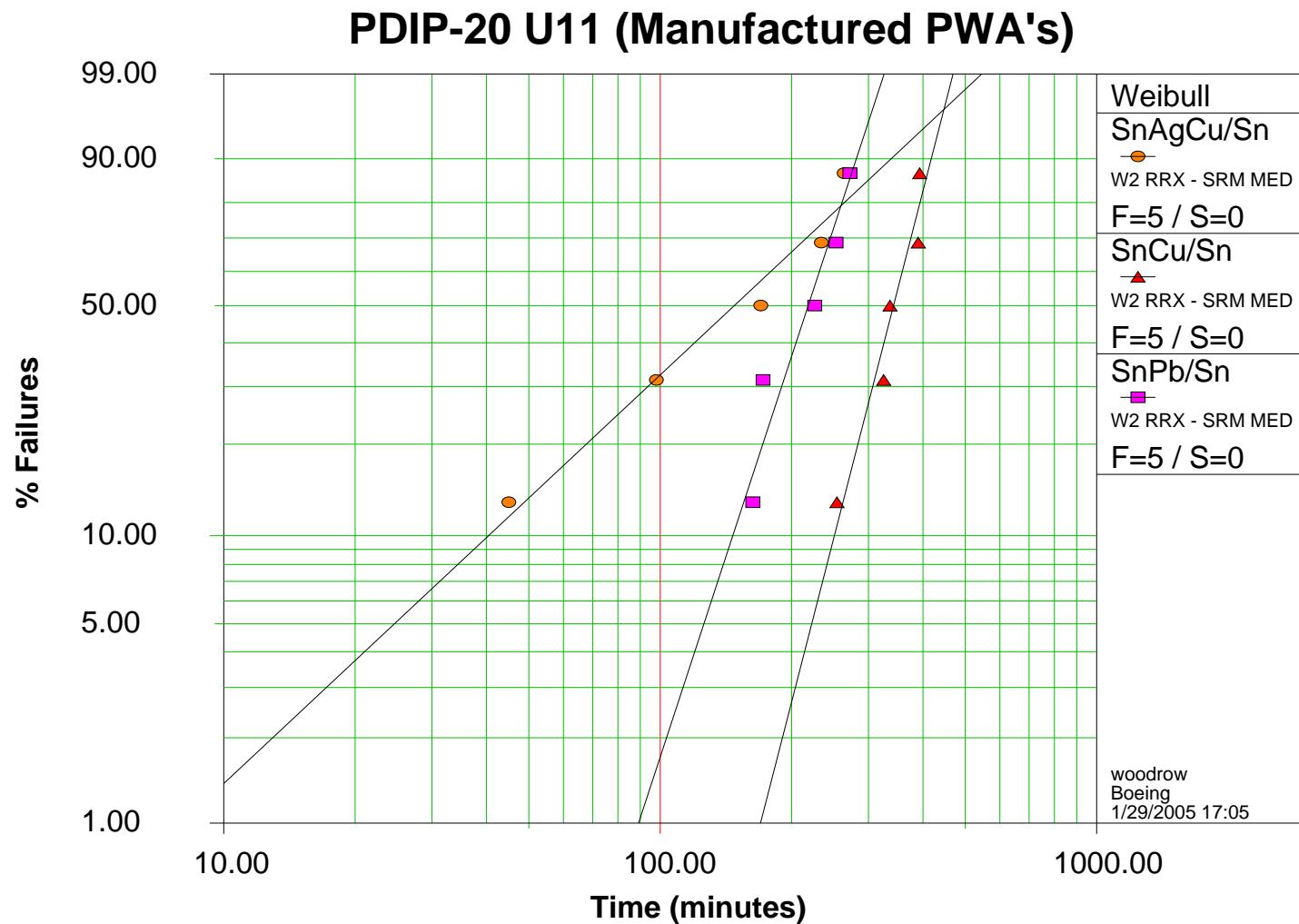
$\beta_3=2.0896$, $\eta_3=30.6710$, $\rho=0.8263$



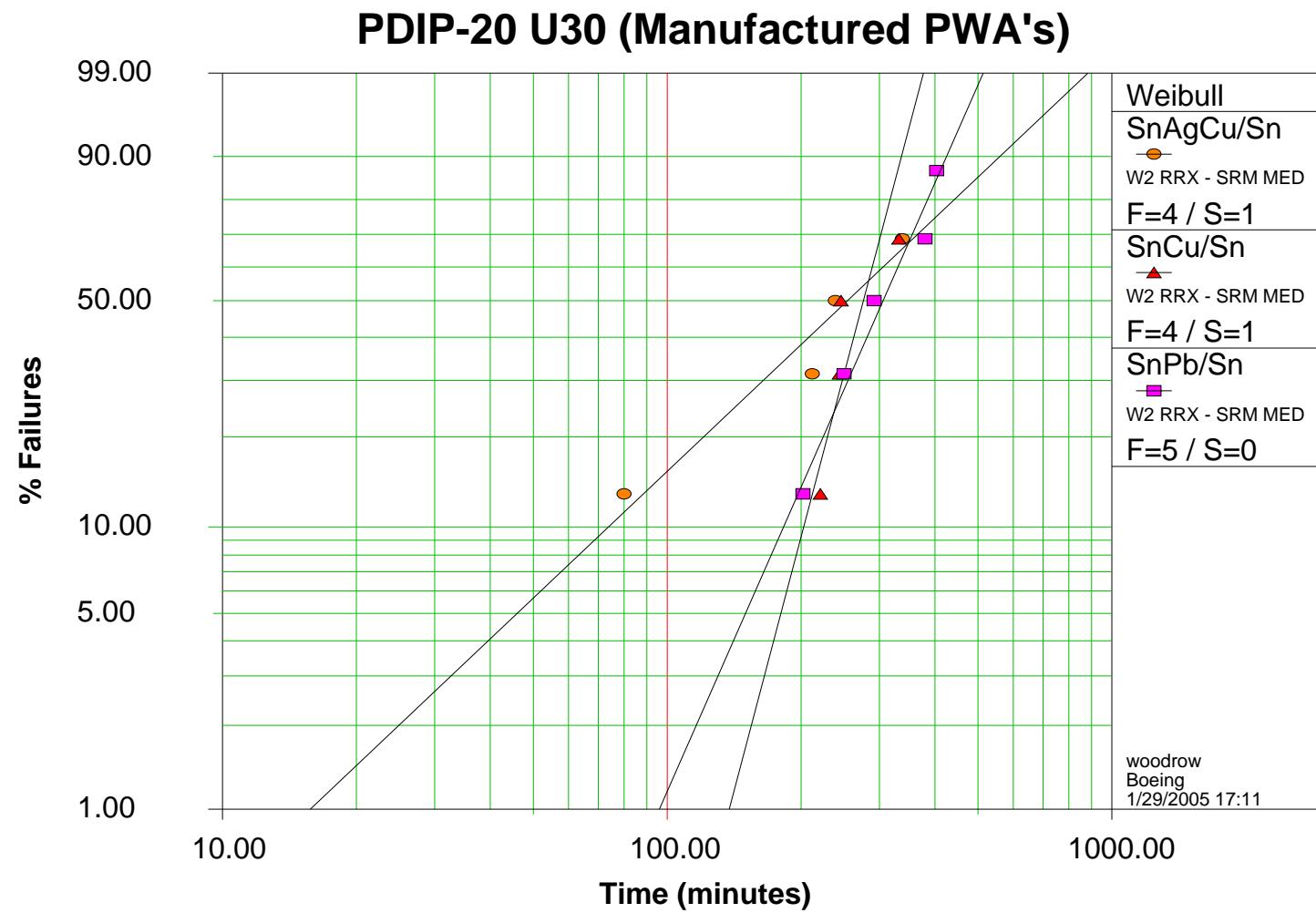
$\beta_1=4.9131, \eta_1=200.7584, \rho=0.9881$
 $\beta_2=18.8513, \eta_2=389.3978, \rho=0.9204$
 $\beta_3=0.8990, \eta_3=69.3969, \rho=0.9248$



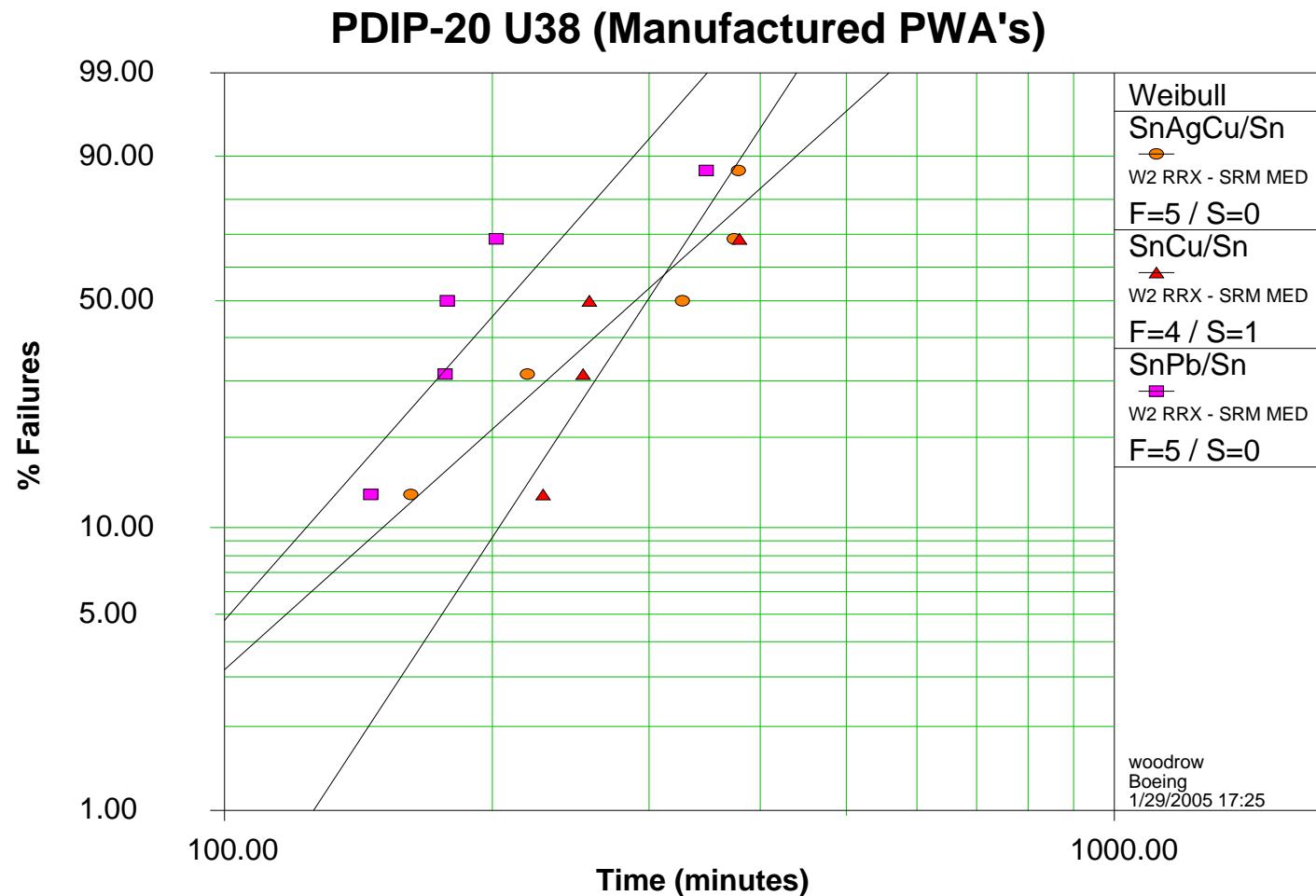
$\beta_1=1.1206, \eta_1=85.6442, \rho=0.9483$
 $\beta_2=4.8894, \eta_2=354.7697, \rho=0.9597$
 $\beta_3=1.3600, \eta_3=42.1976, \rho=0.9929$



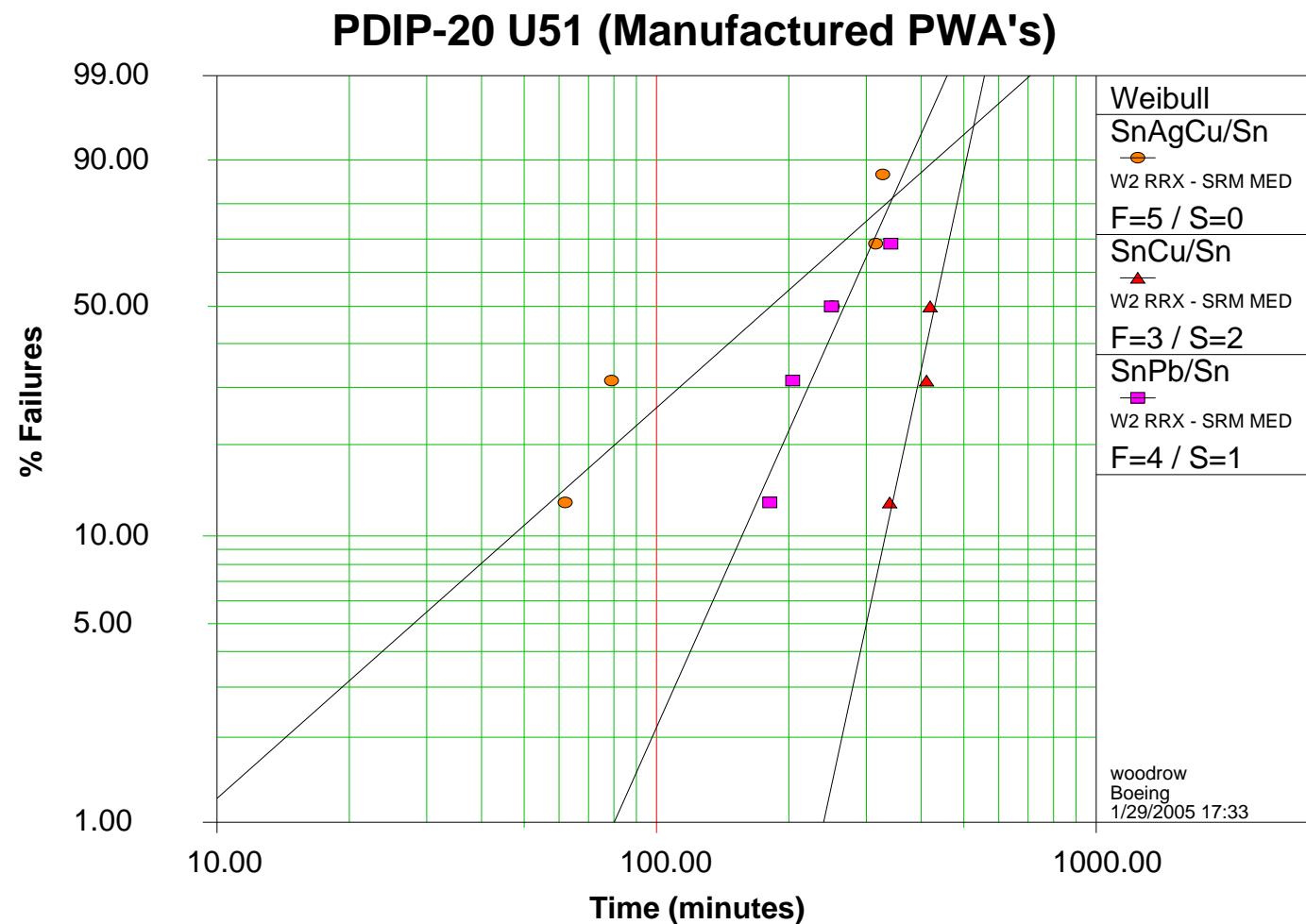
$\beta_1=1.4513, \eta_1=190.6115, \rho=0.9846$
 $\beta_2=6.0338, \eta_2=363.9681, \rho=0.9698$
 $\beta_3=4.7290, \eta_3=236.0587, \rho=0.9585$



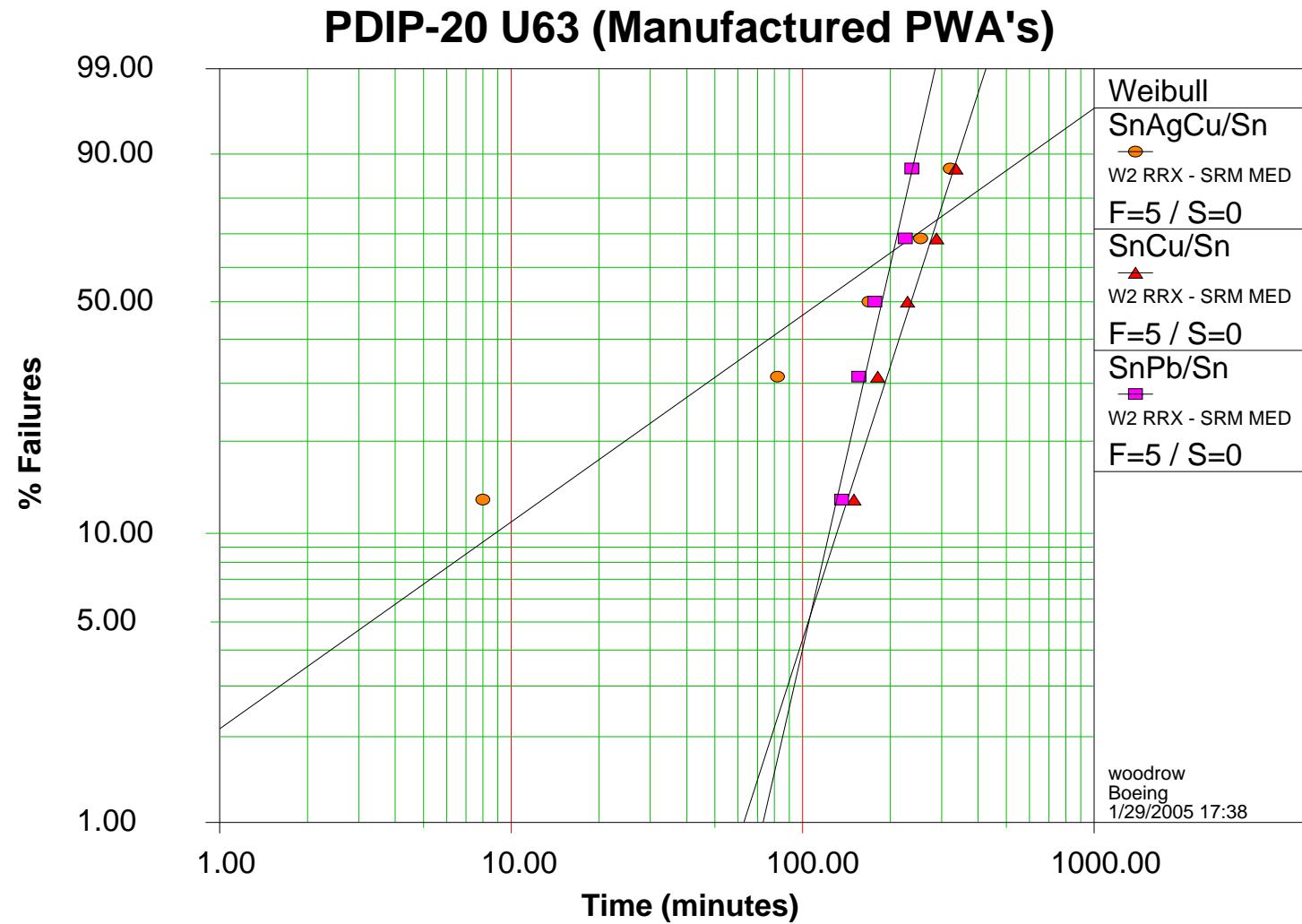
$\beta_1=1.5216, \eta_1=323.9607, \rho=0.9714$
 $\beta_2=6.0931, \eta_2=293.4114, \rho=0.8512$
 $\beta_3=3.6526, \eta_3=338.3607, \rho=0.9847$



$$\begin{aligned}\beta_1 &= 2.8831, \eta_1 = 328.8336, \rho = 0.9656 \\ \beta_2 &= 4.9026, \eta_2 = 321.8425, \rho = 0.8341 \\ \beta_3 &= 3.6398, \eta_3 = 229.3789, \rho = 0.8663\end{aligned}$$



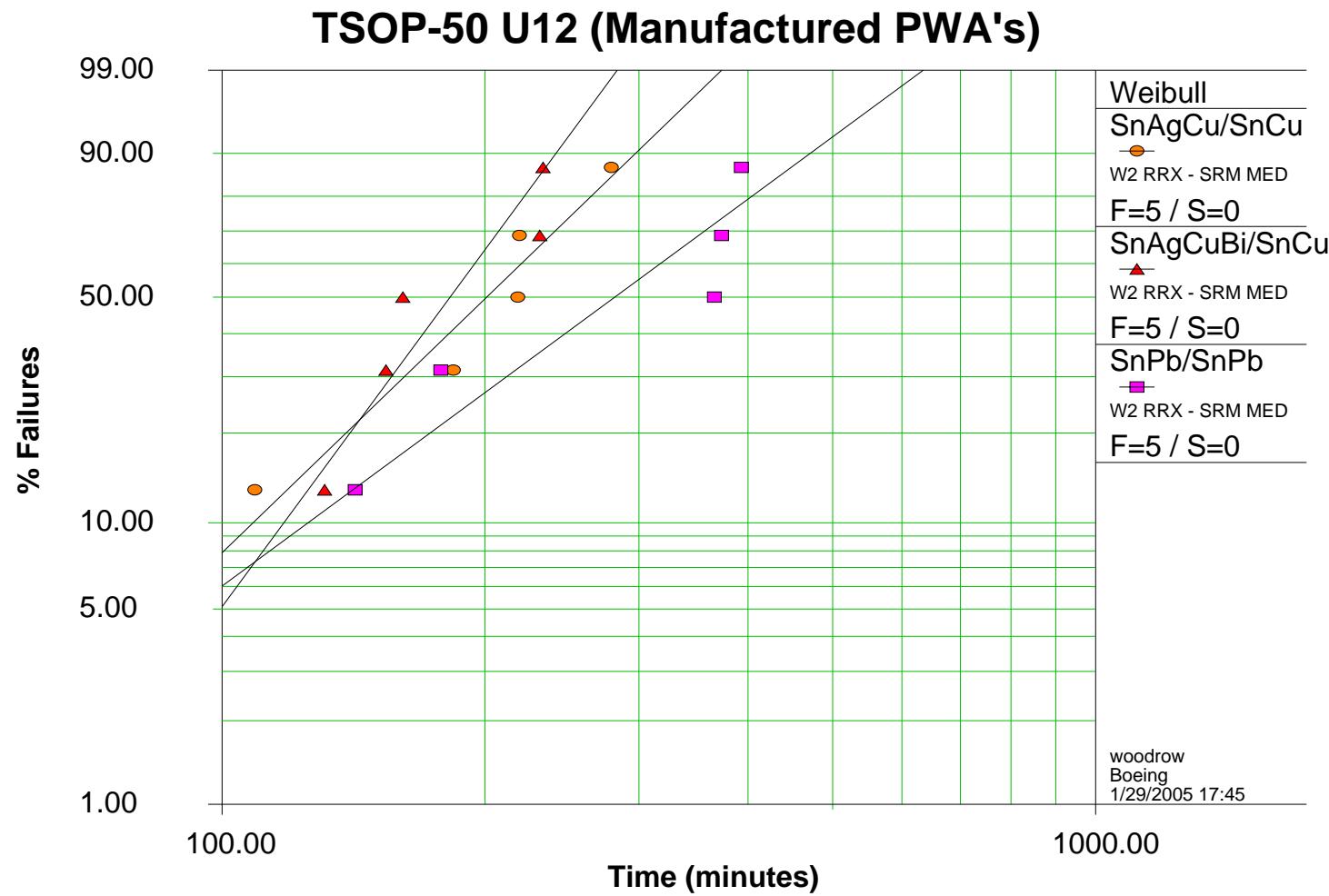
$\beta_1=1.3926, \eta_1=236.4377, \rho=0.9323$
 $\beta_2=7.2652, \eta_2=451.7370, \rho=0.9546$
 $\beta_3=3.5137, \eta_3=296.8242, \rho=0.9375$



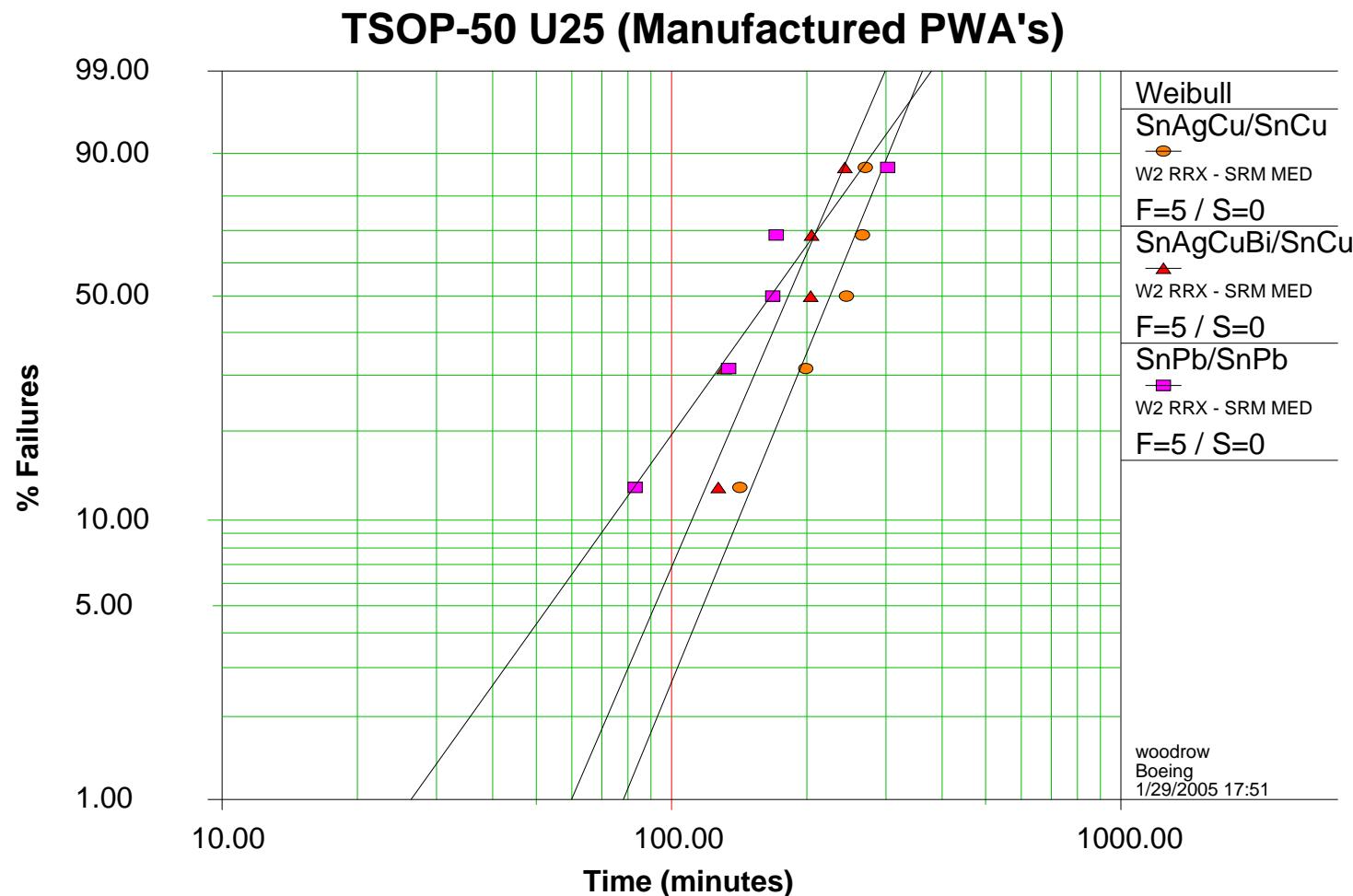
$\beta_1=0.7303, \eta_1=192.0408, \rho=0.9528$

$\beta_2=3.2047, \eta_2=264.3538, \rho=0.9876$

$\beta_3=4.5085, \eta_3=203.0660, \rho=0.9737$

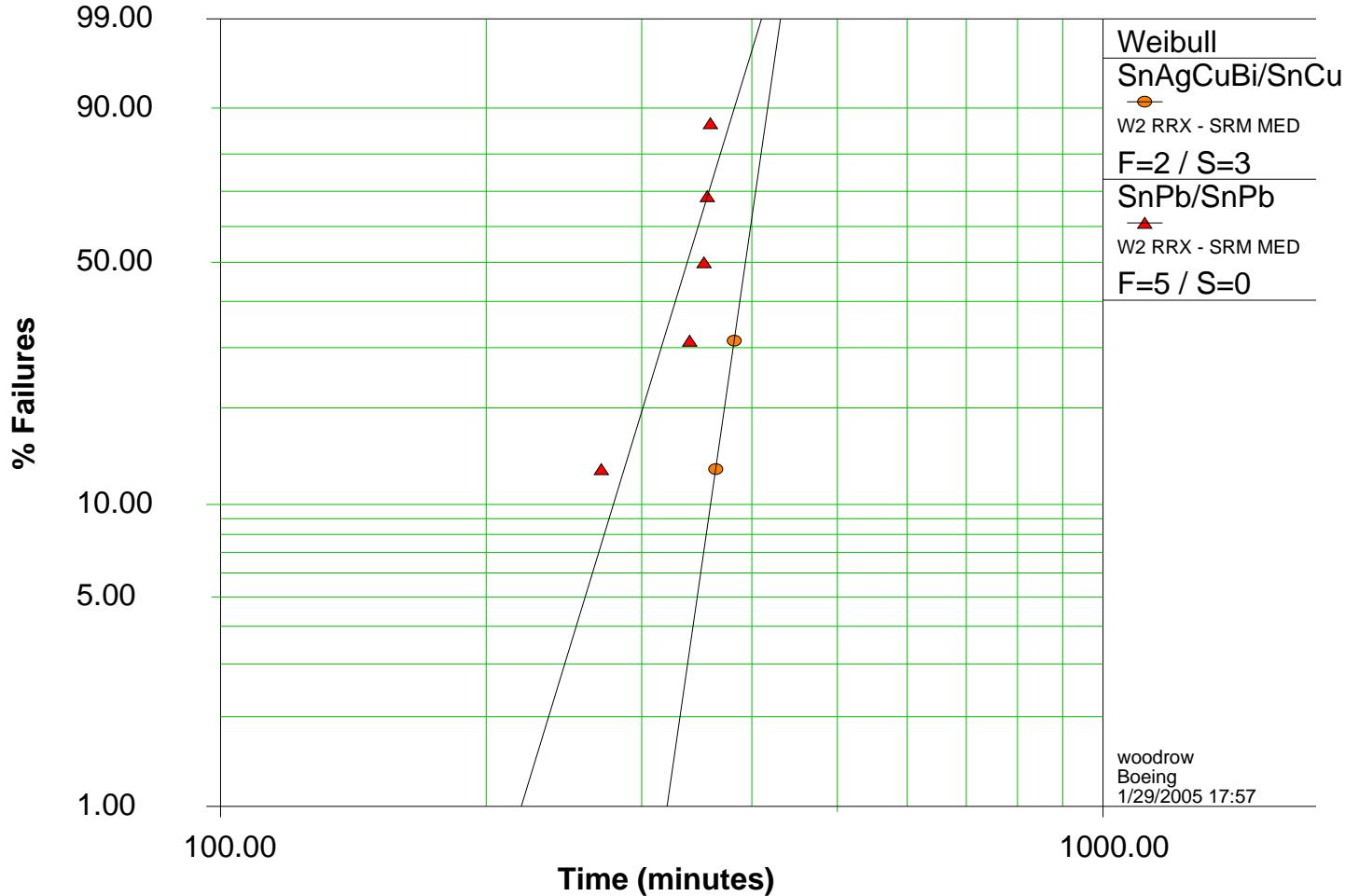


$\beta_1=3.0588$, $\eta_1=226.5179$, $\rho=0.9654$
 $\beta_2=4.3005$, $\eta_2=198.6688$, $\rho=0.9381$
 $\beta_3=2.3301$, $\eta_3=329.6278$, $\rho=0.9280$

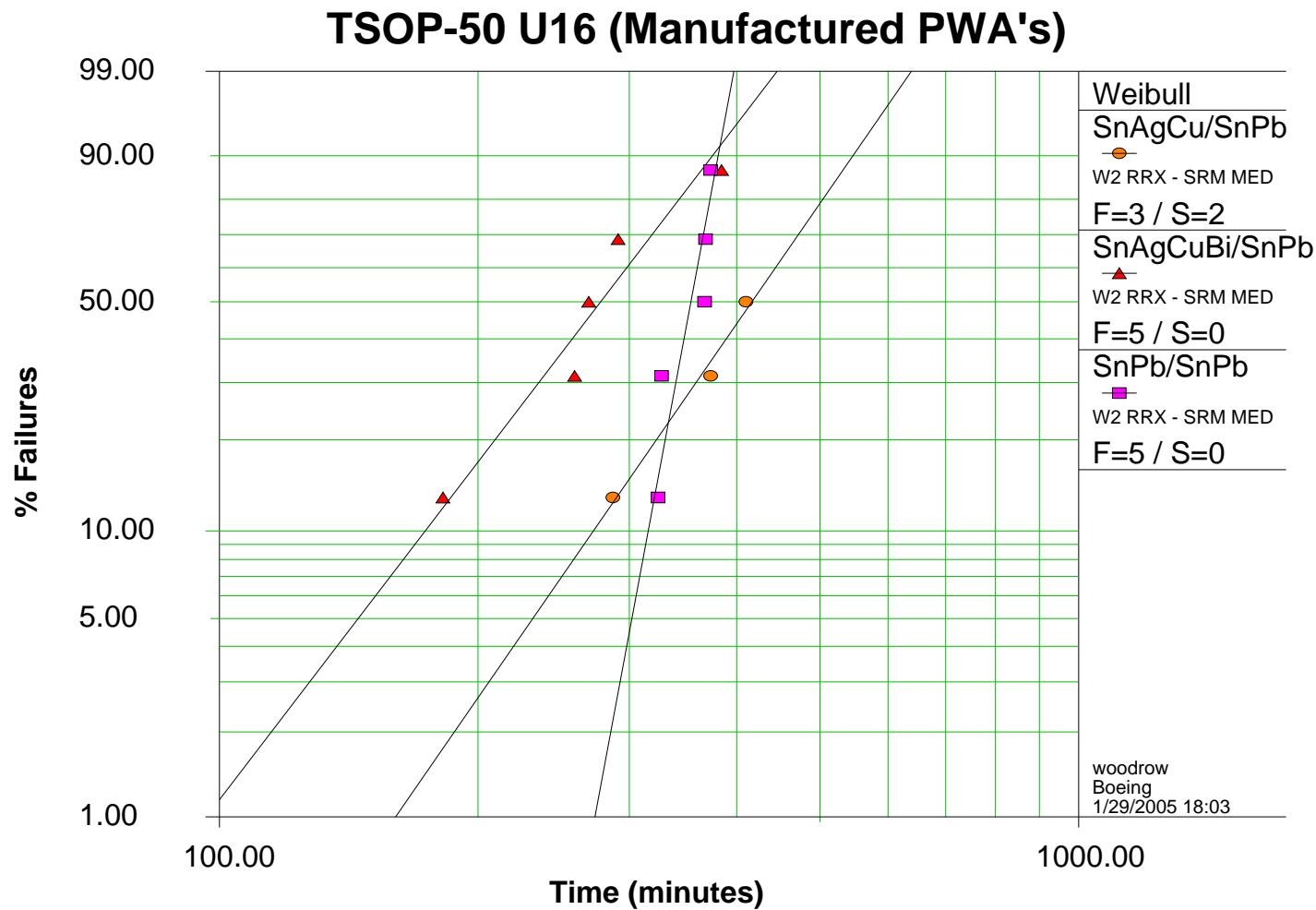


$\beta_1=3.9972, \eta_1=246.9944, \rho=0.9637$
 $\beta_2=3.8127, \eta_2=200.2503, \rho=0.9310$
 $\beta_3=2.2980, \eta_3=194.9992, \rho=0.9665$

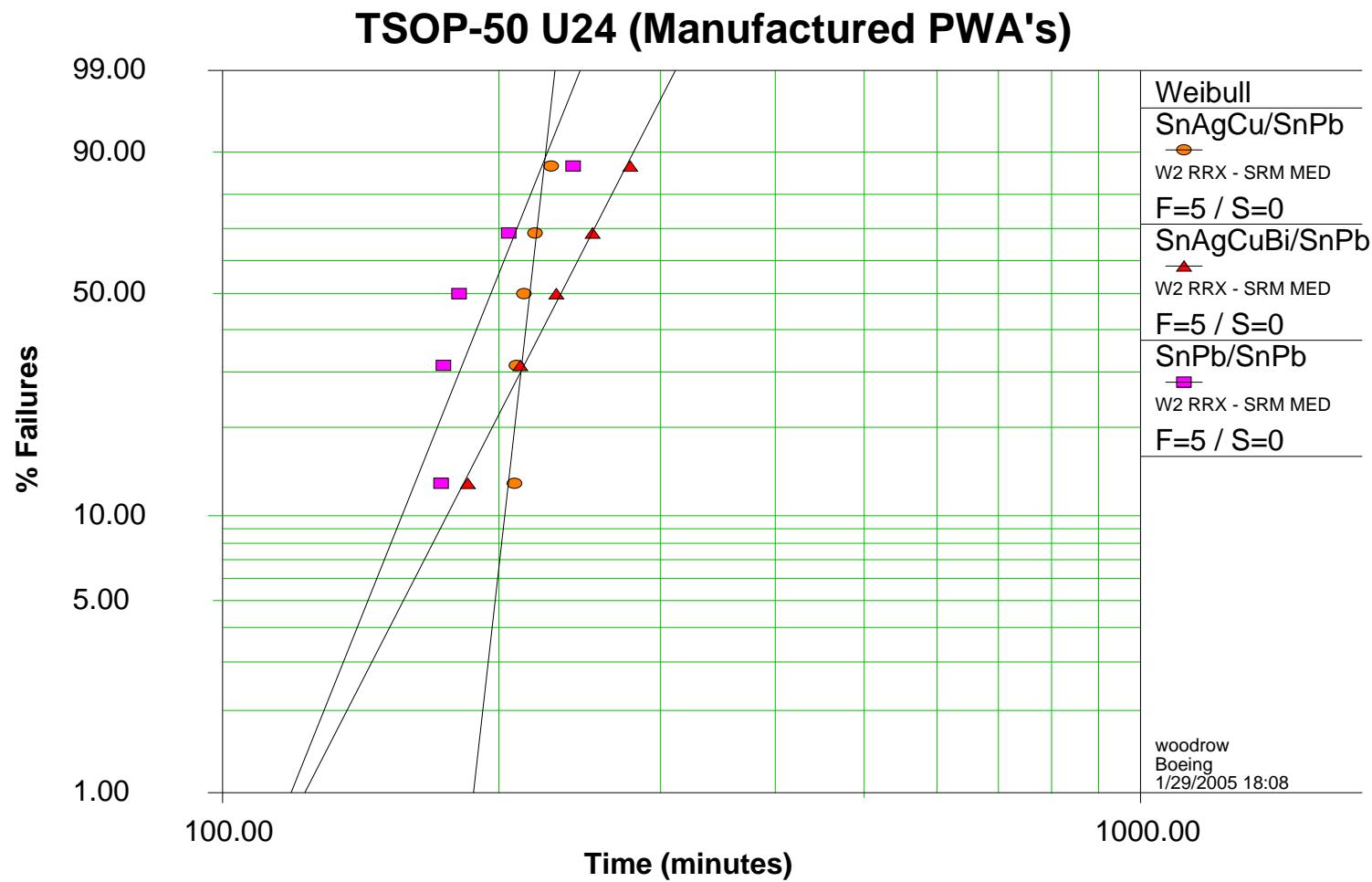
TSOP-50 U29 (Manufactured PWA's)



$\beta_1=20.7054$, $\eta_1=400.4487$, $\rho=1.0000$
 $\beta_2=9.7731$, $\eta_2=350.9647$, $\rho=0.8837$



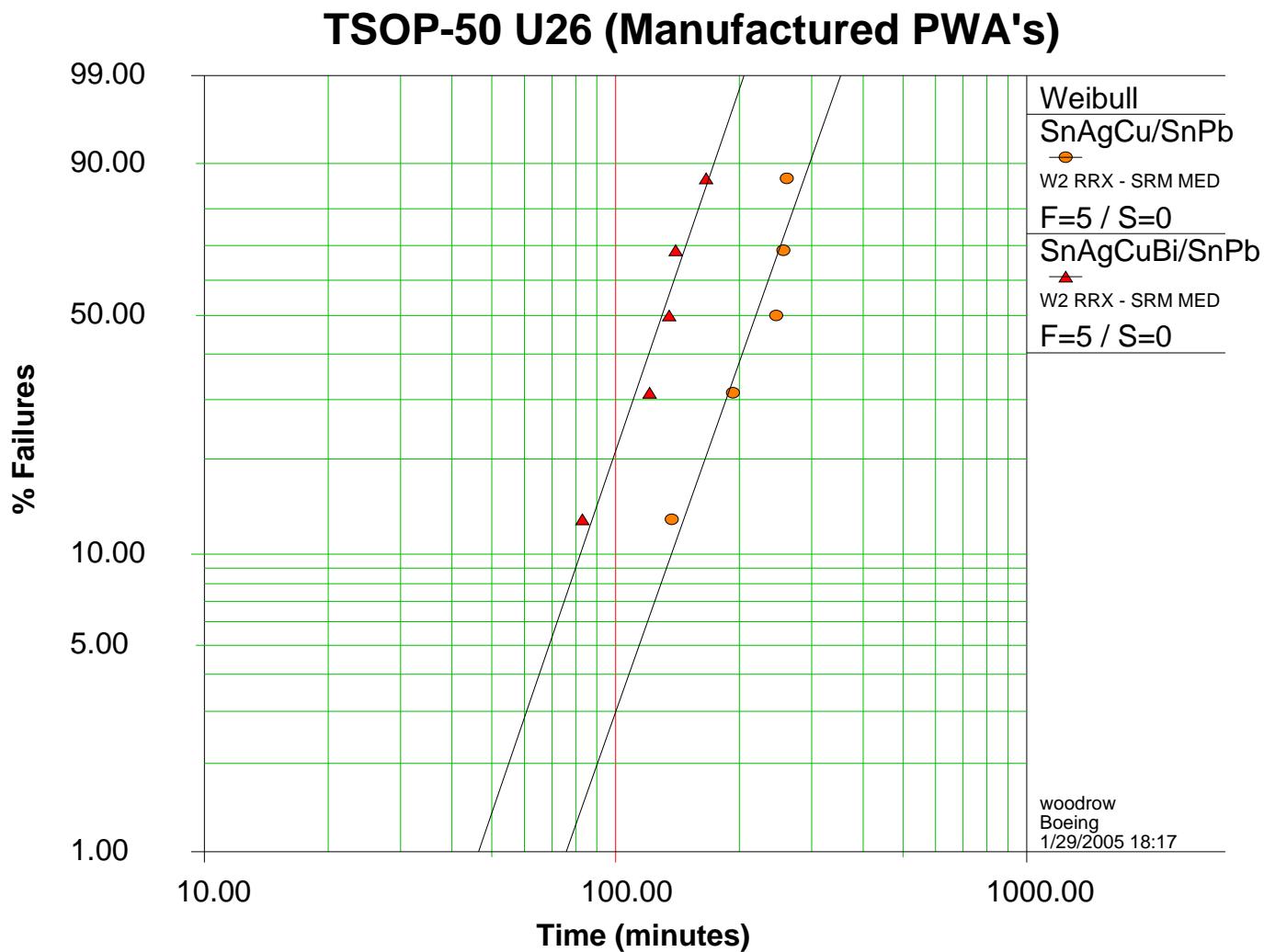
$\beta_1=4.4325, \eta_1=452.7493, \rho=0.9921$
 $\beta_2=4.0061, \eta_2=304.4584, \rho=0.9684$
 $\beta_3=16.4637, \eta_3=361.7615, \rho=0.9076$



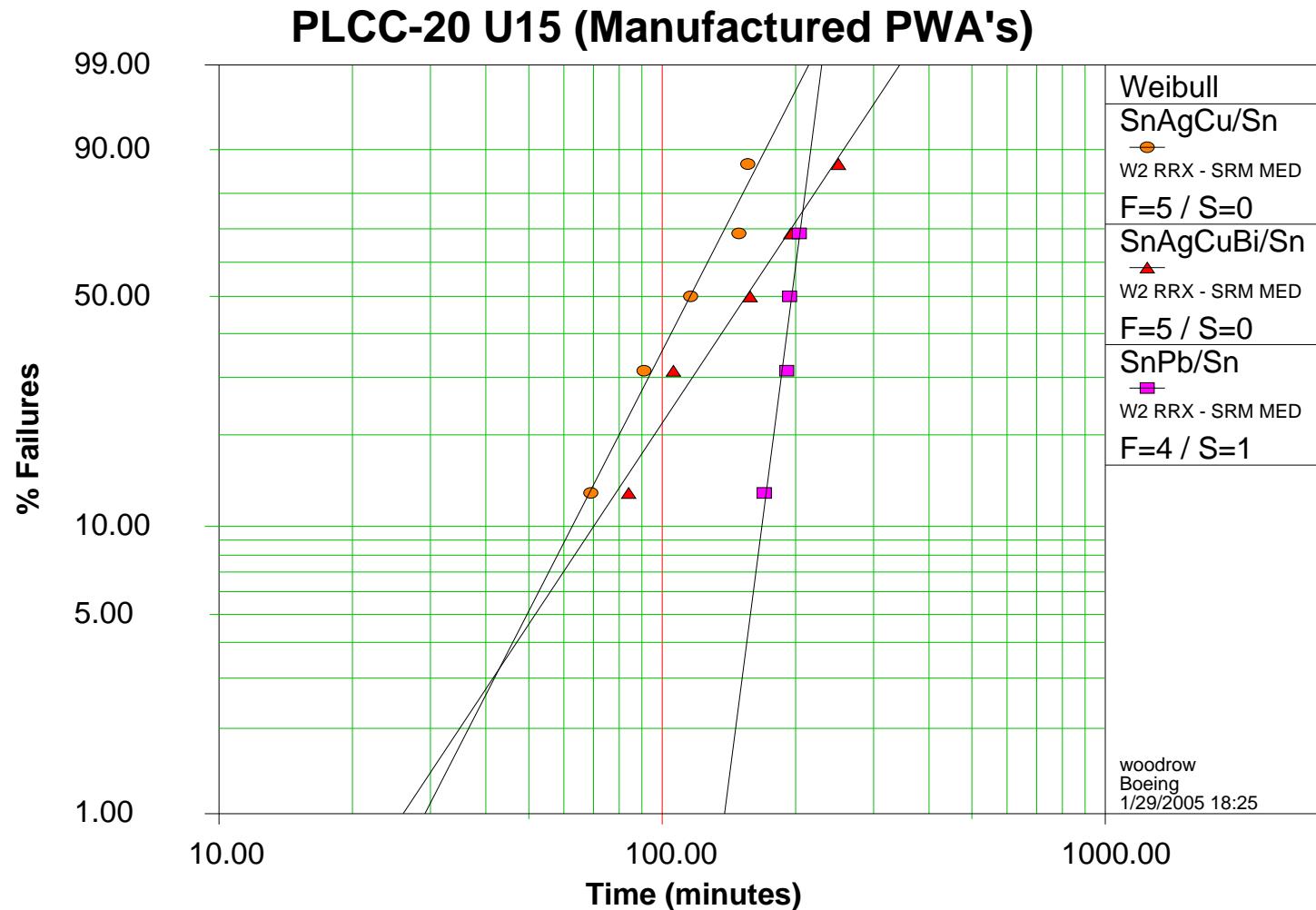
$\beta_1=29.9268, \eta_1=218.8381, \rho=0.9148$

$\beta_2=6.5918, \eta_2=247.0662, \rho=0.9978$

$\beta_3=8.4486, \eta_3=204.7682, \rho=0.8708$



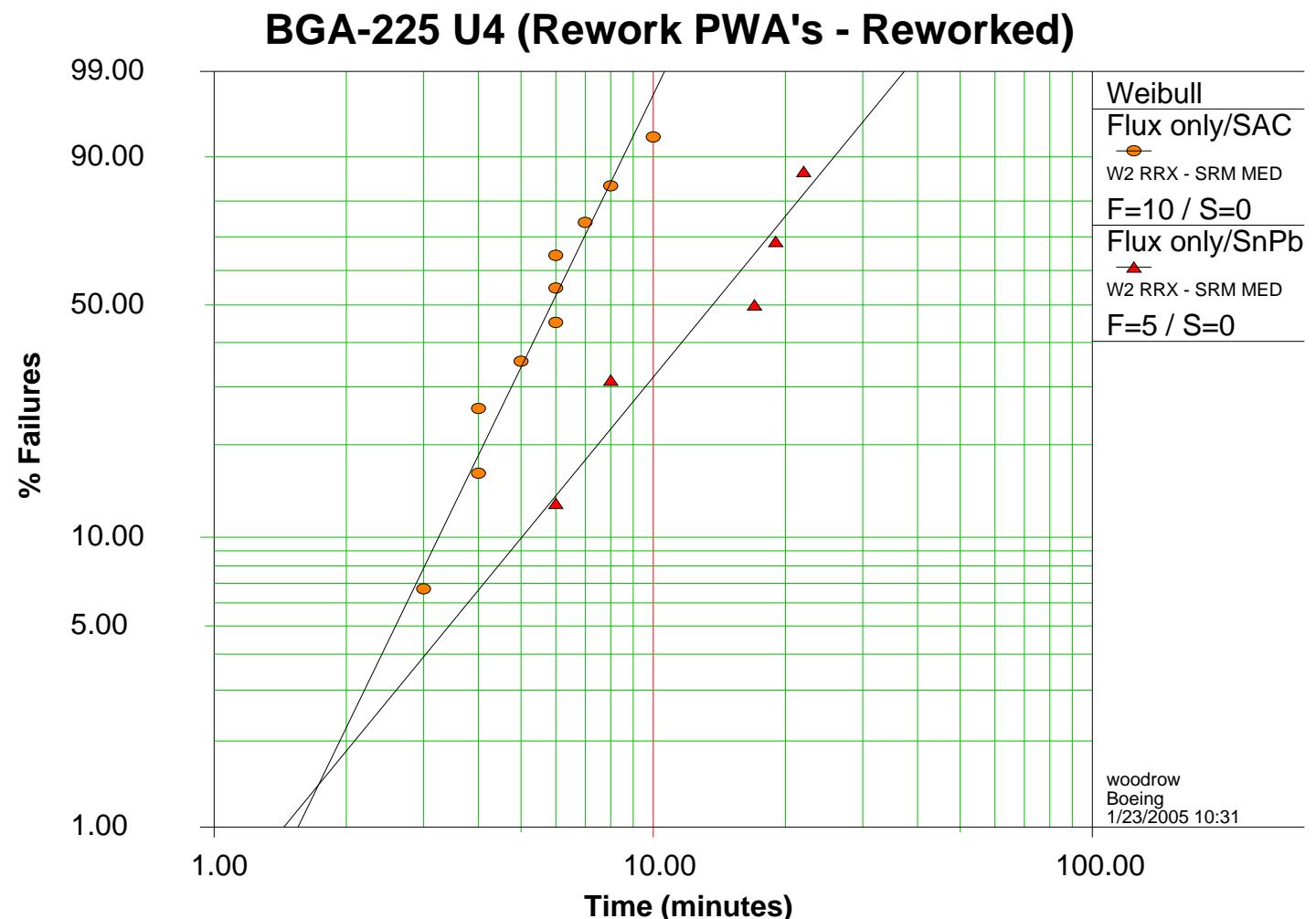
$\beta_1=3.9854, \eta_1=240.5214, \rho=0.9515$
 $\beta_2=4.1213, \eta_2=141.7283, \rho=0.9745$



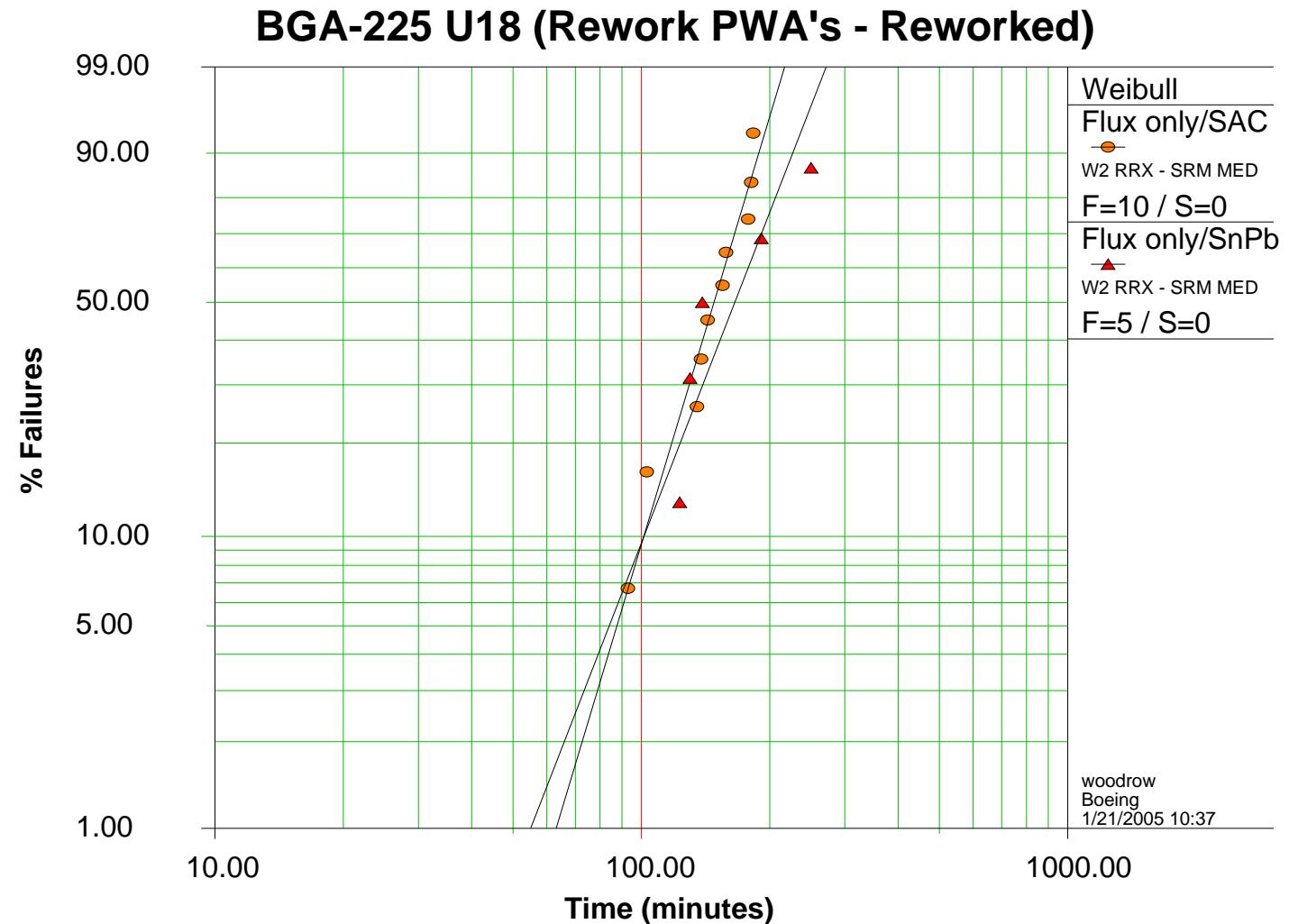
$$\beta_1 = 3.0708, \eta_1 = 130.3799, \rho = 0.9872$$

$$\beta_2 = 2.3734, \eta_2 = 180.7751, \rho = 0.9869$$

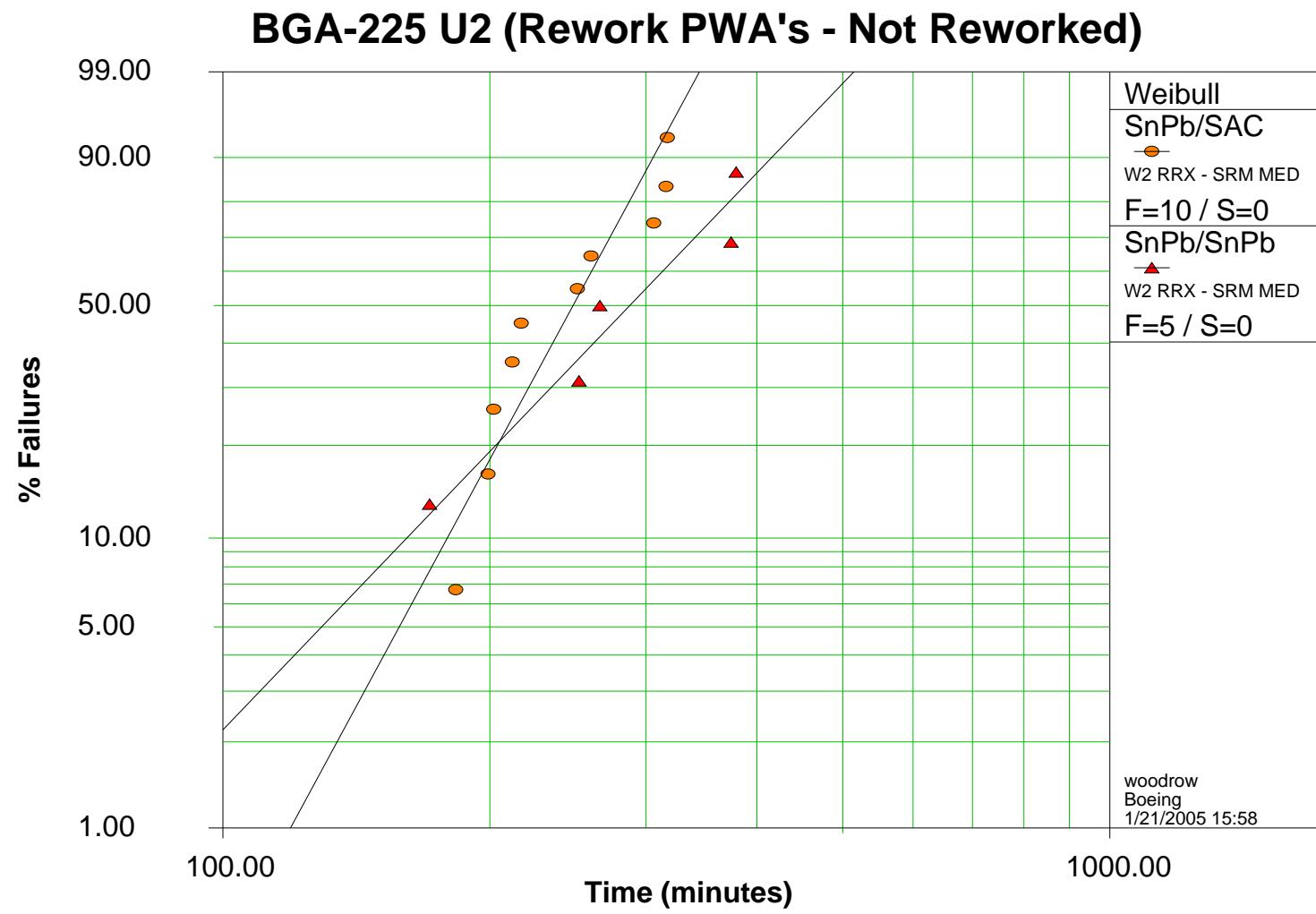
$$\beta_3 = 12.1122, \eta_3 = 202.1426, \rho = 0.9773$$



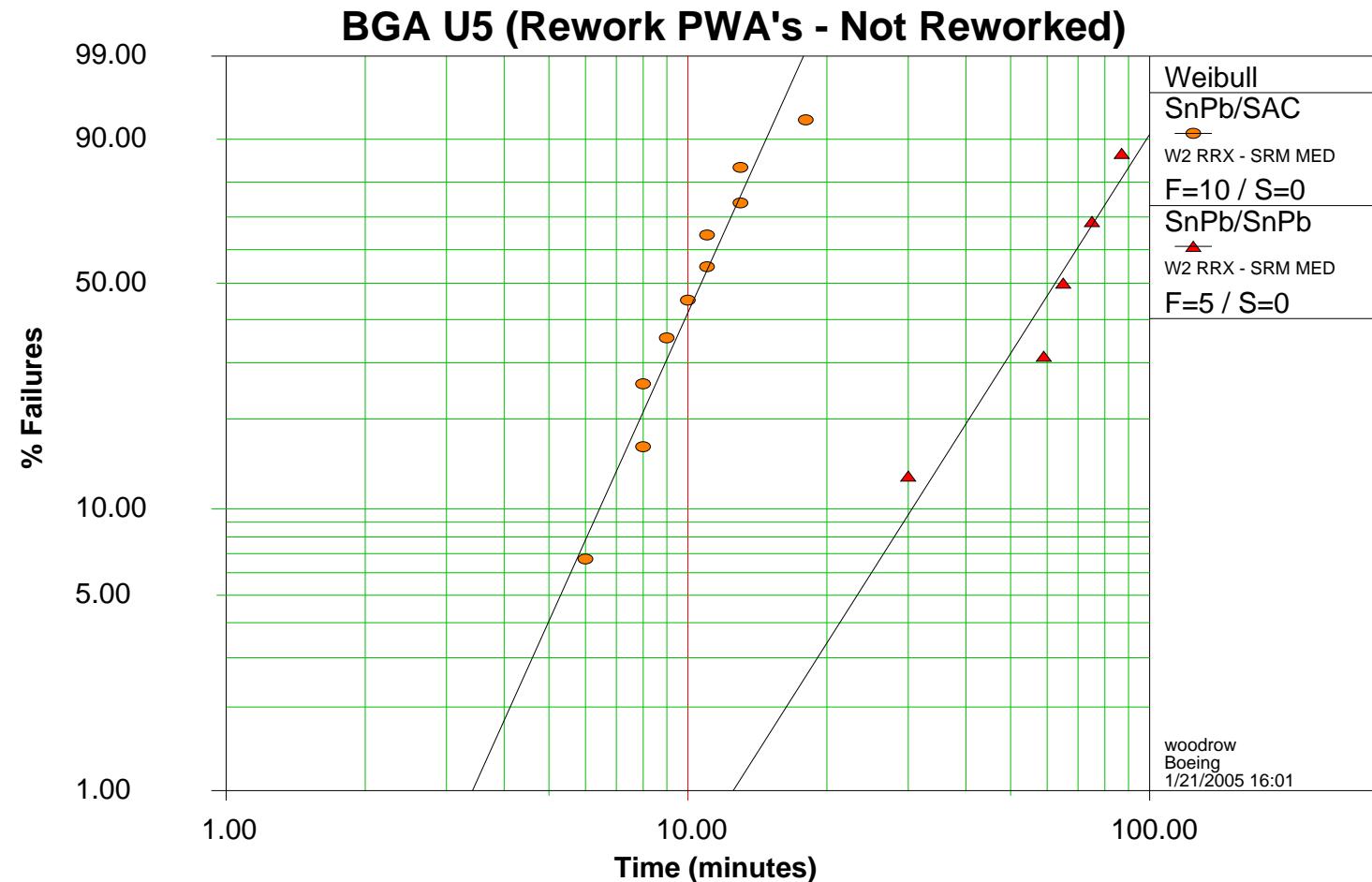
$\beta_1 = 3.1869$, $\eta_1 = 6.5721$, $\rho = 0.9793$
 $\beta_2 = 1.8826$, $\eta_2 = 16.5923$, $\rho = 0.9591$



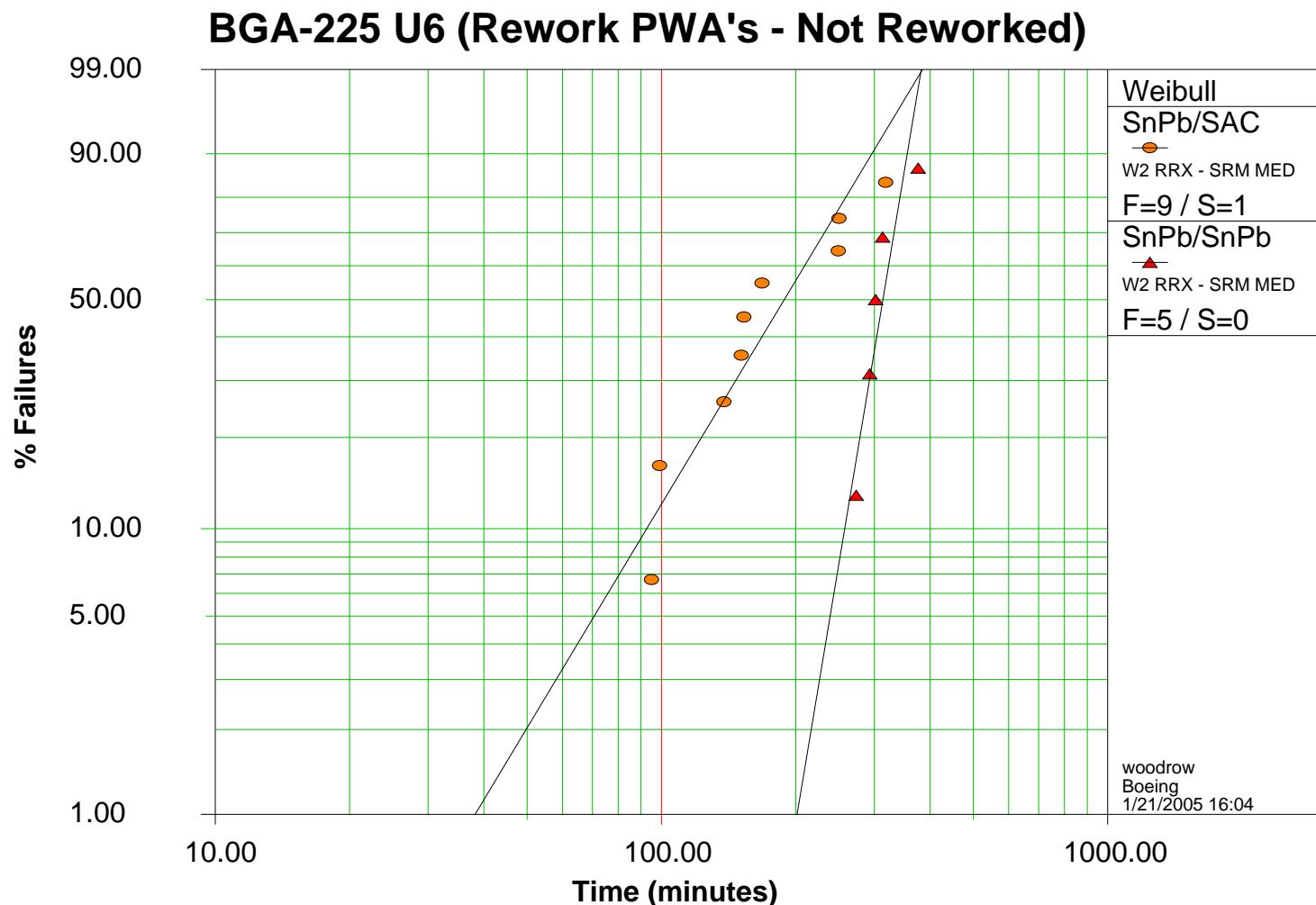
$$\beta_1 = 4.9647, \eta_1 = 159.3988, \rho = 0.9777$$
$$\beta_2 = 3.8383, \eta_2 = 182.2864, \rho = 0.8992$$



$\beta_1=5.7720, \eta_1=264.5390, \rho=0.9382$
 $\beta_2=3.2546, \eta_2=321.8951, \rho=0.9719$

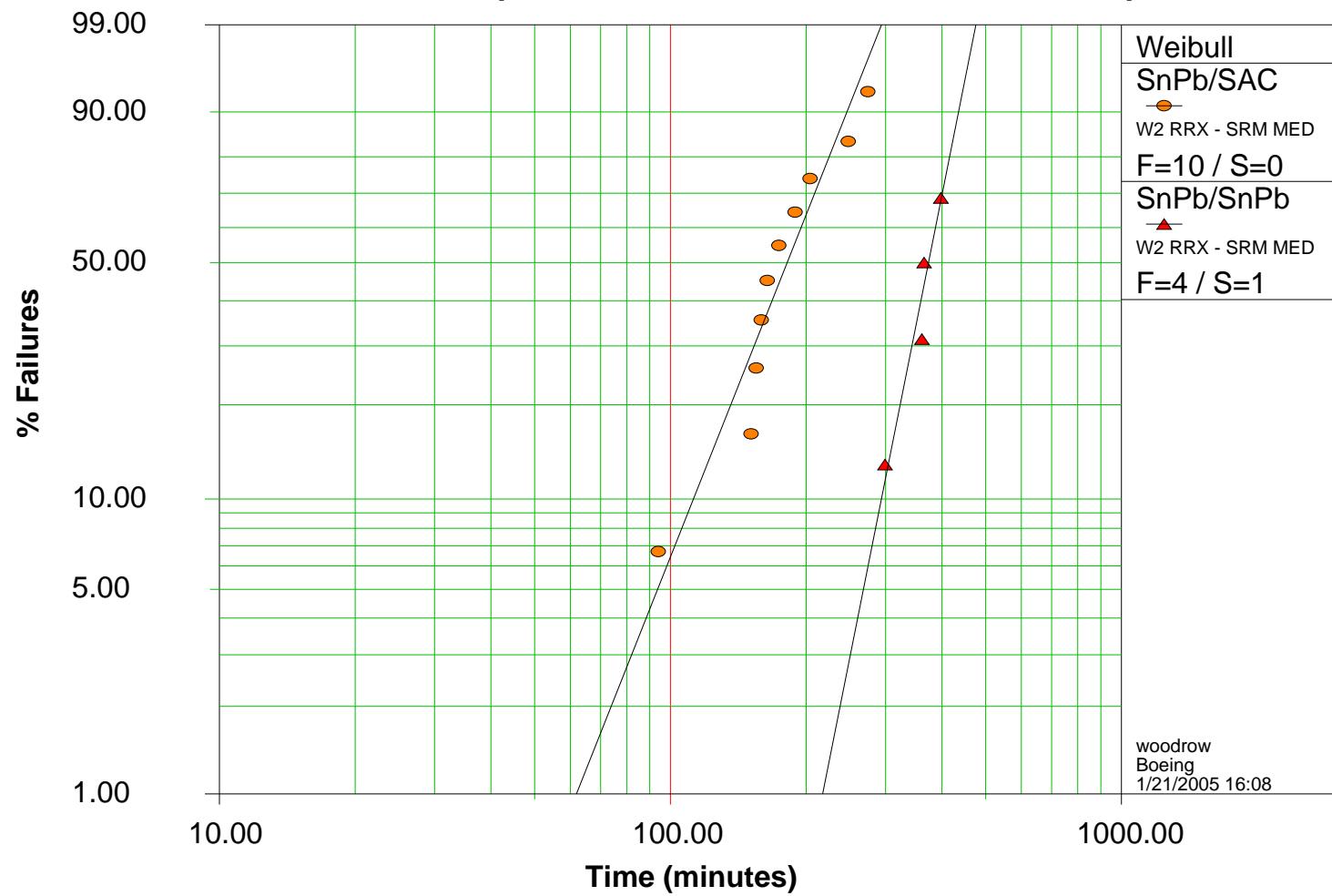


$$\begin{aligned}\beta_1 &= 3.7116, \eta_1 = 11.7971, p = 0.9709 \\ \beta_2 &= 2.6366, \eta_2 = 71.7820, p = 0.9596\end{aligned}$$

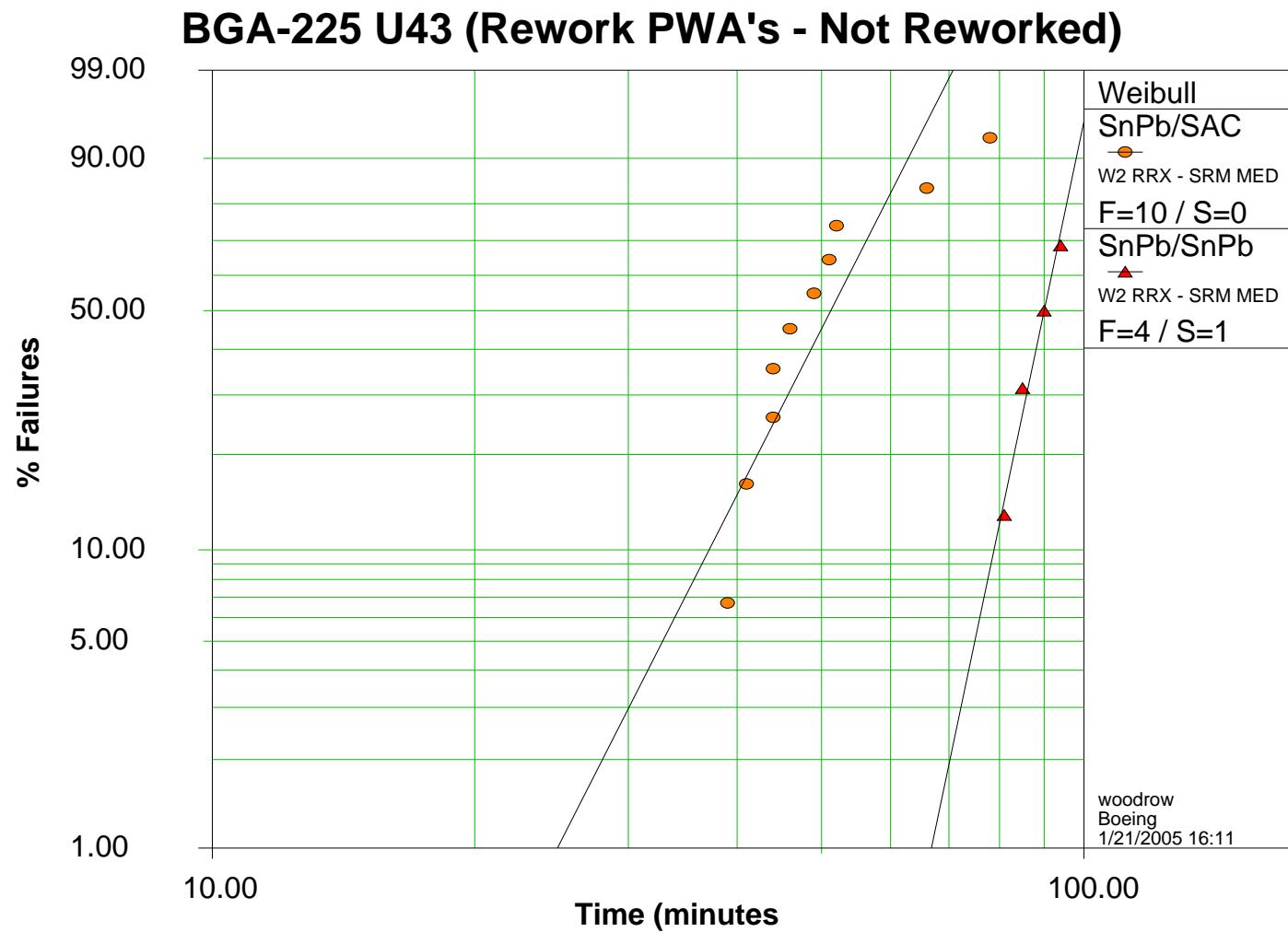


$\beta_1=2.6528$, $\eta_1=216.5265$, $\rho=0.9454$
 $\beta_2=9.5587$, $\eta_2=325.8927$, $\rho=0.9078$

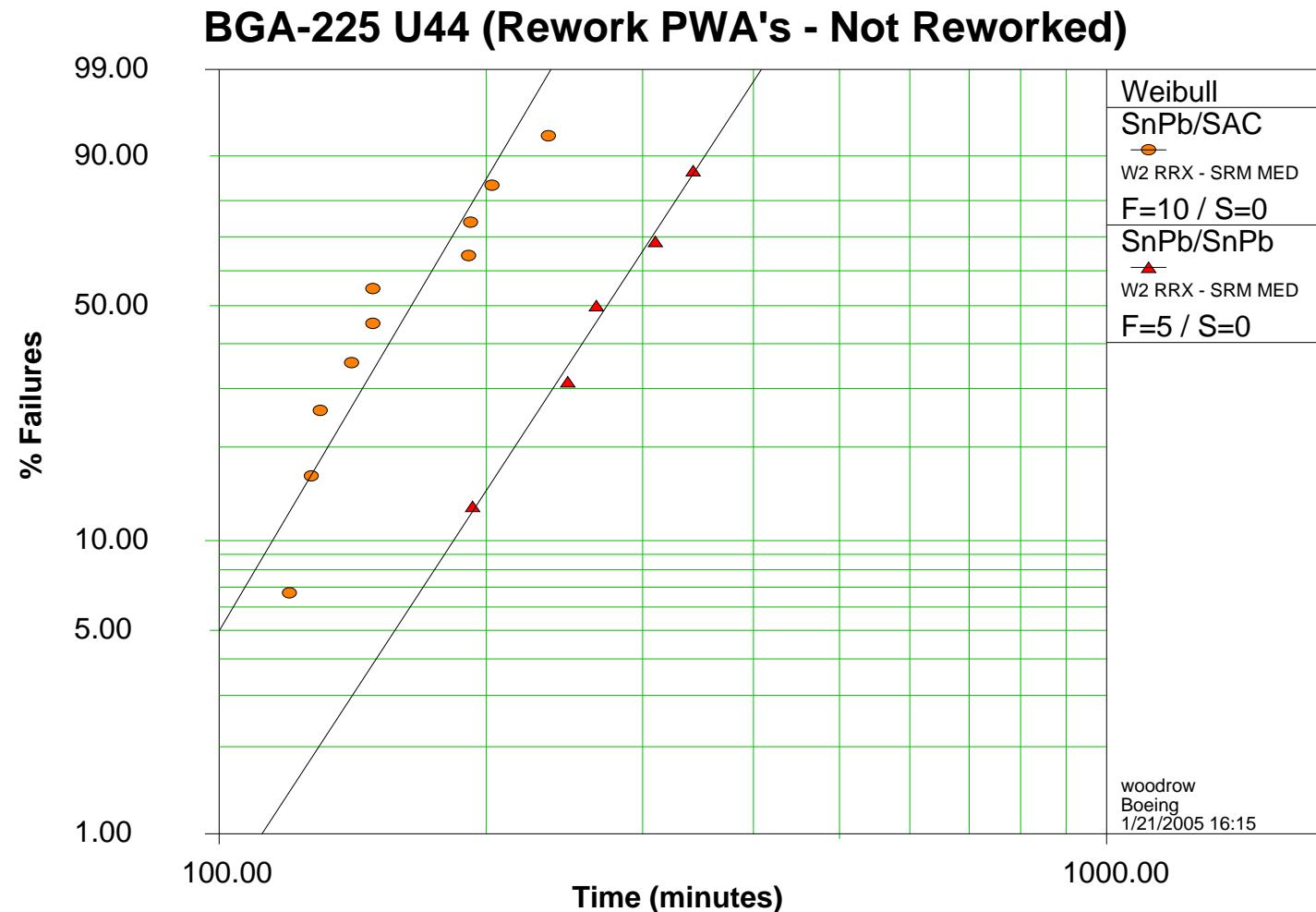
BGA-225 U21 (Rework PWA's - Not Reworked)



$$\begin{aligned}\beta_1 &= 3.9350, \eta_1 = 199.3399, \rho = 0.9607 \\ \beta_2 &= 7.8260, \eta_2 = 391.5958, \rho = 0.9680\end{aligned}$$

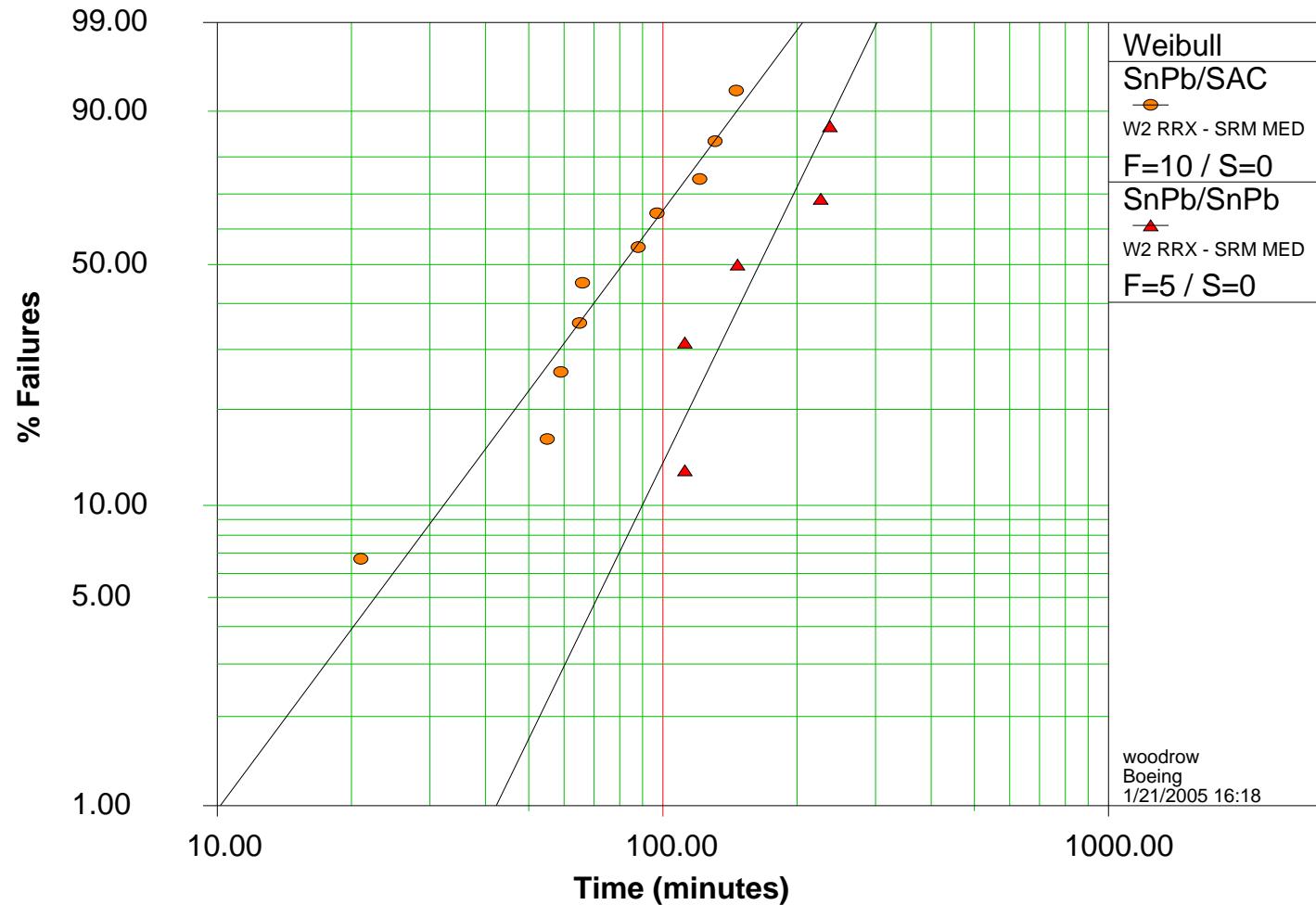


$\beta_1=5.8614$, $\eta_1=54.5410$, $p=0.8857$
 $\beta_2=14.1986$, $\eta_2=92.3784$, $p=0.9874$



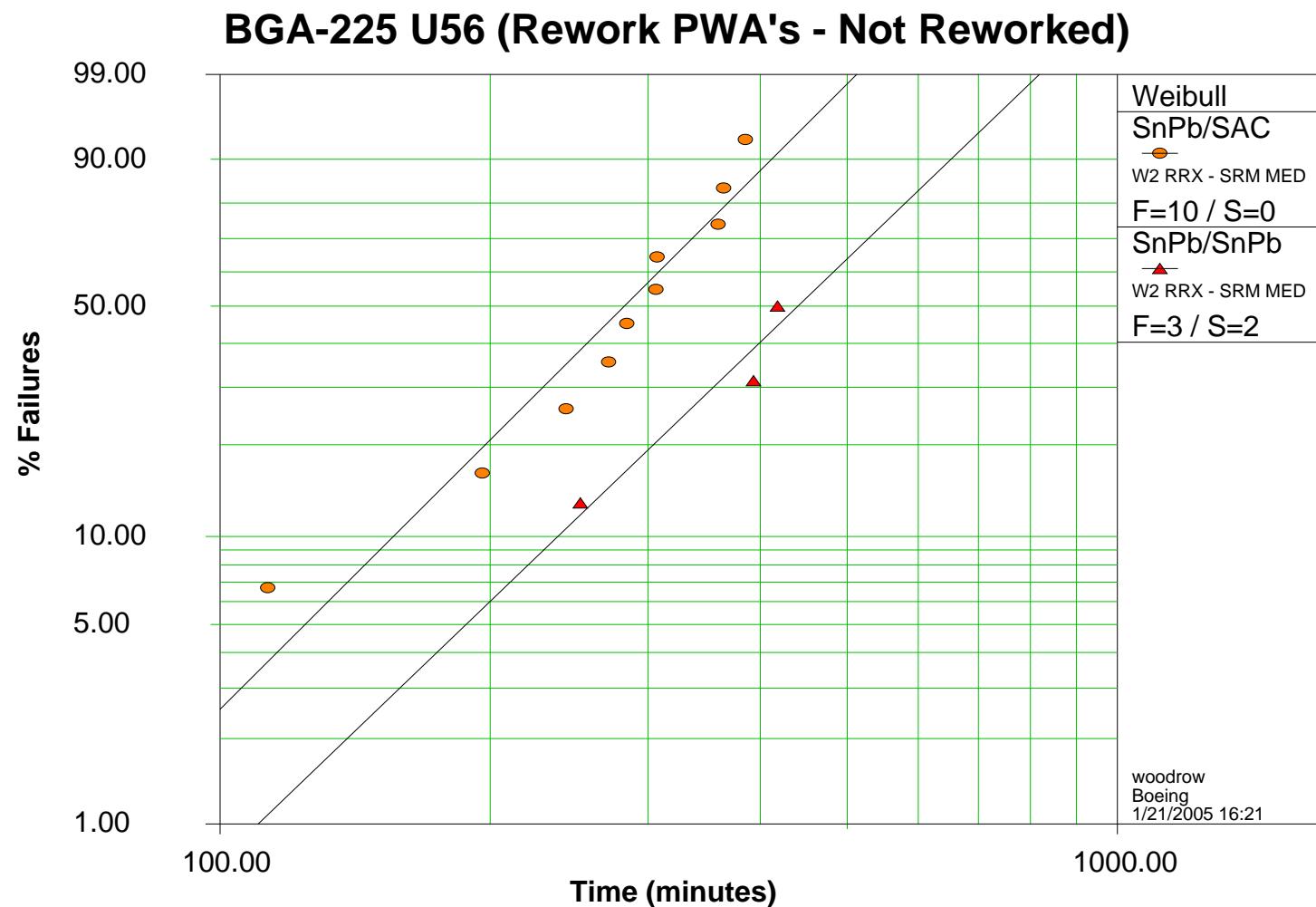
$\beta_1=5.2281, \eta_1=176.6352, \rho=0.9320$
 $\beta_2=4.7292, \eta_2=295.6786, \rho=0.9952$

BGA-225 U55 (Rework PWA's - Not Reworked)



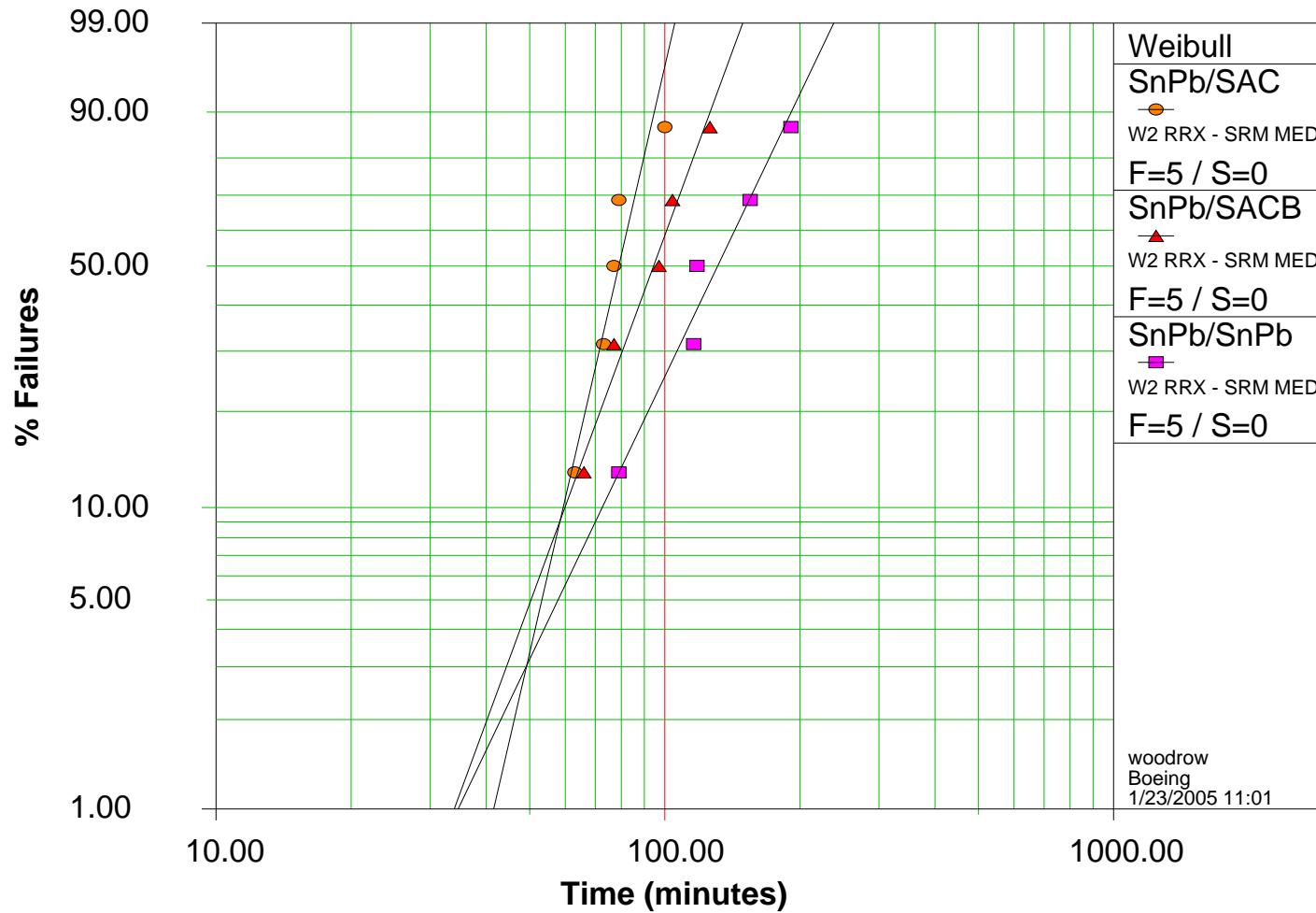
$\beta_1=2.0353$, $\eta_1=97.2715$, $\rho=0.9705$

$\beta_2=3.1145$, $\eta_2=185.1082$, $\rho=0.9126$



$$\begin{aligned}\beta_1 &= 3.1770, \eta_1 = 316.8222, p = 0.9630 \\ \beta_2 &= 3.0560, \eta_2 = 496.8350, p = 0.9630\end{aligned}$$

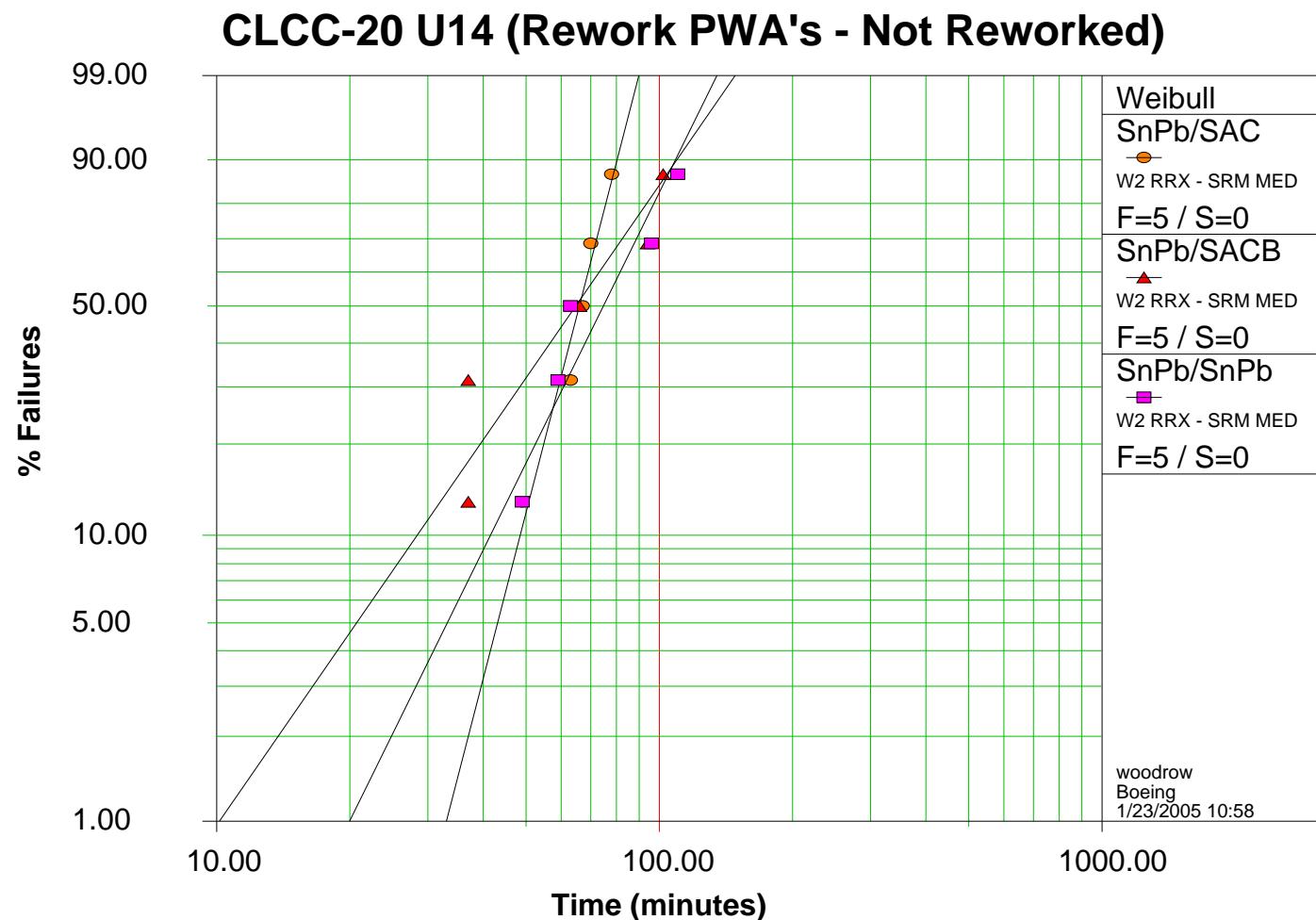
CLCC-20 U13 (Rework PWA's - Not Reworked)



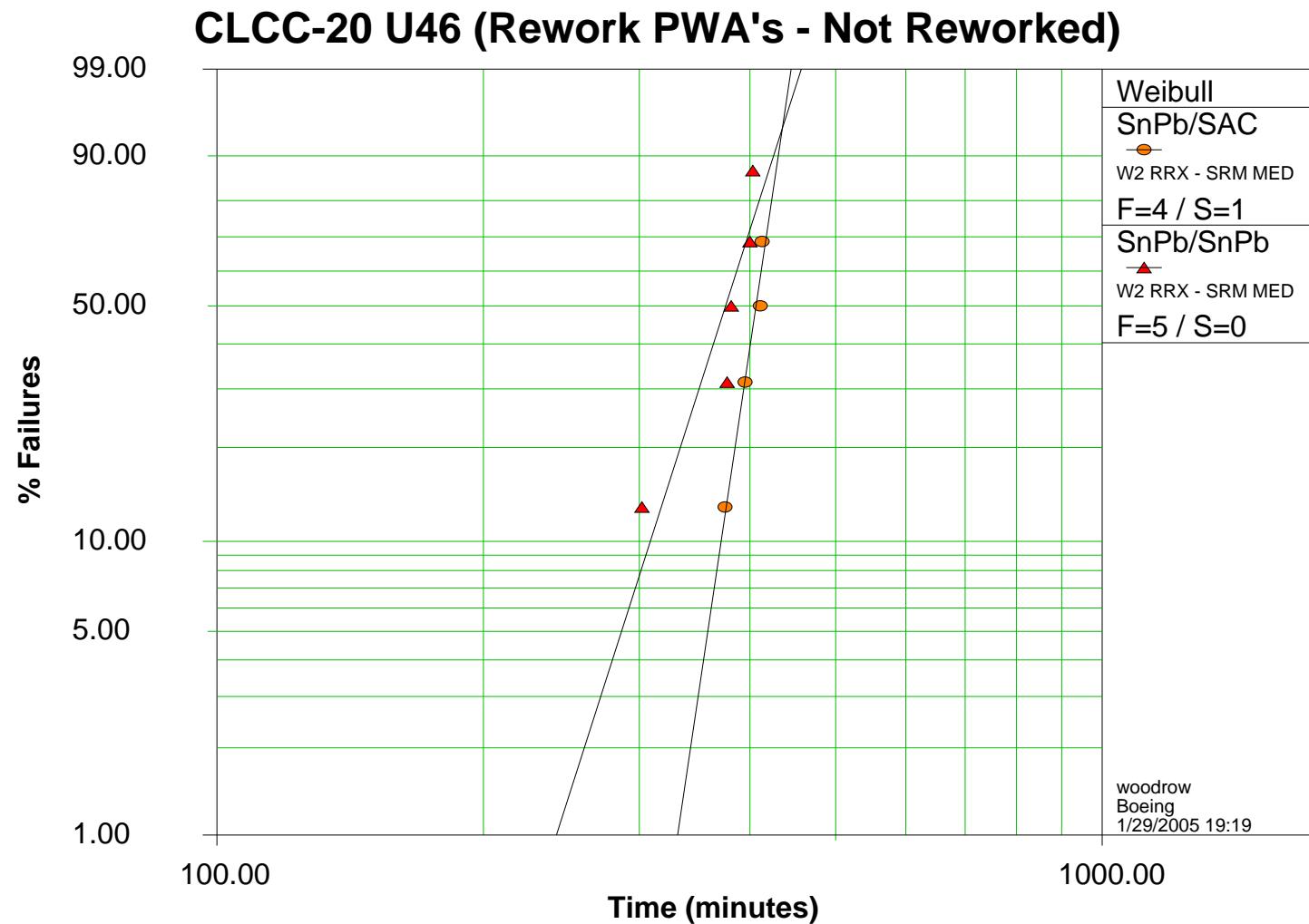
$\beta_1=6.5885$, $\eta_1=83.5102$, $\rho=0.9431$

$\beta_2=4.1375$, $\eta_2=103.1830$, $\rho=0.9876$

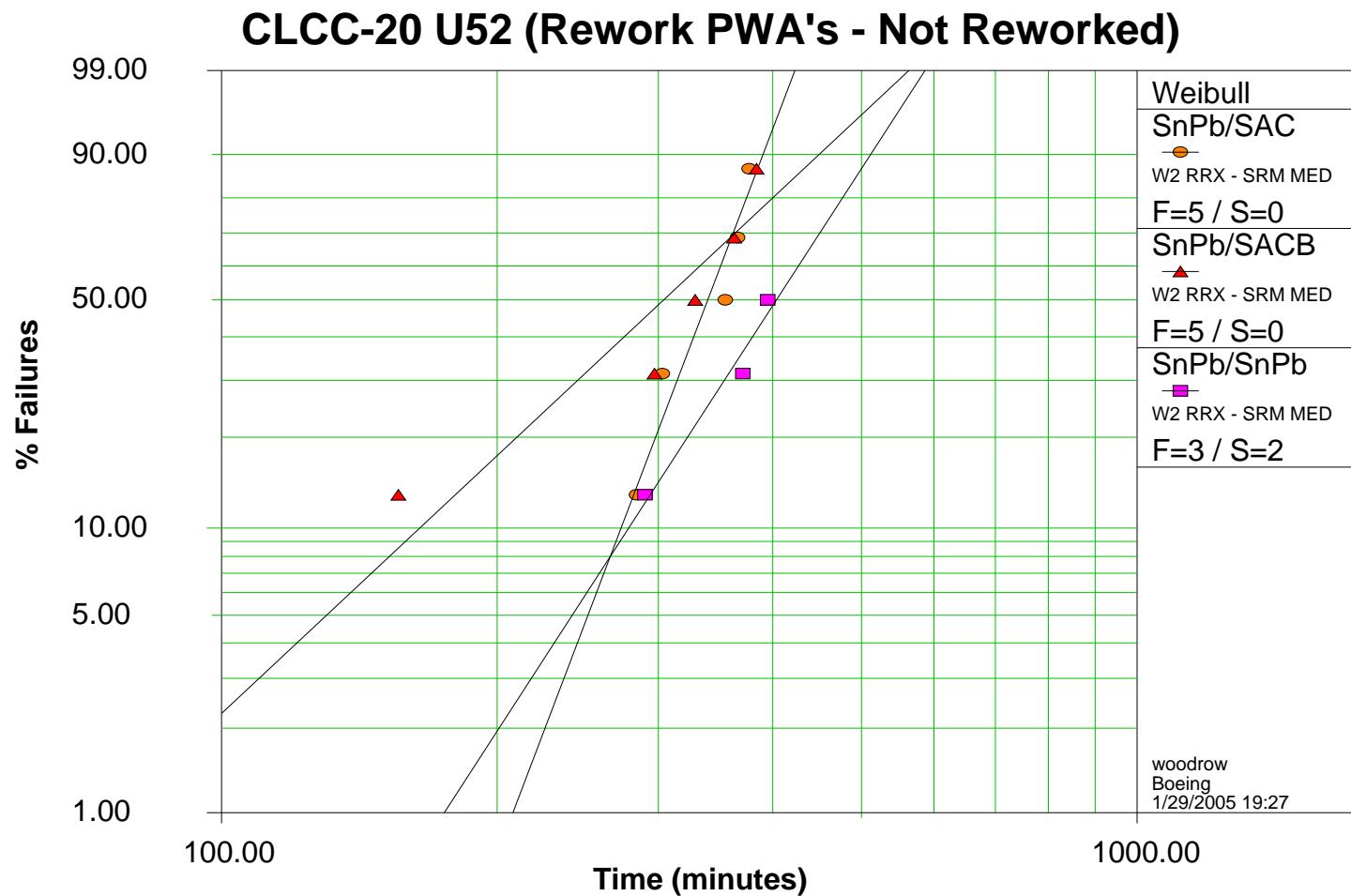
$\beta_3=3.1774$, $\eta_3=147.3039$, $\rho=0.9804$



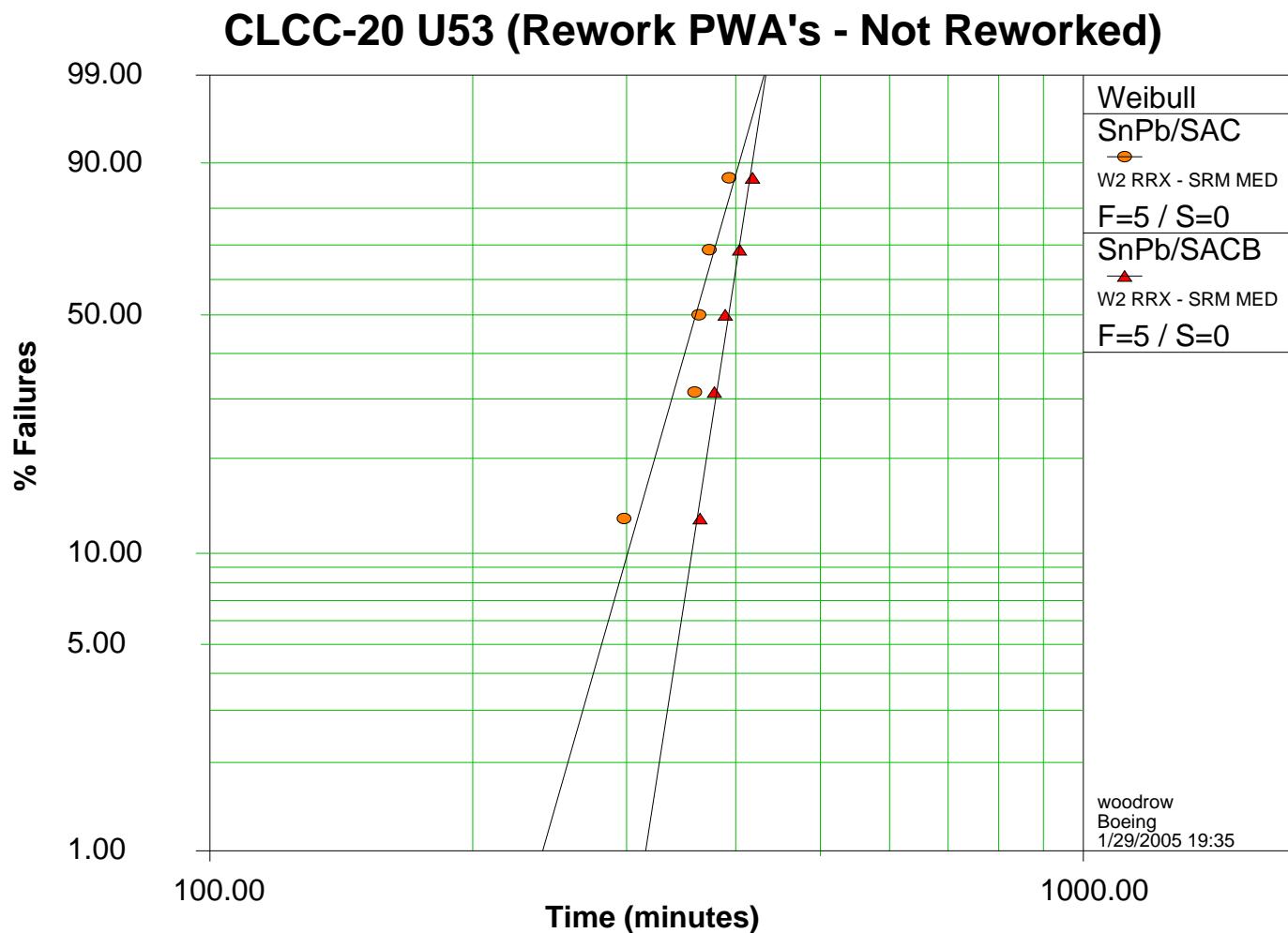
$\beta_1 = 6.1194, \eta_1 = 70.0530, \rho = 0.9790$
 $\beta_2 = 2.2837, \eta_2 = 76.0260, \rho = 0.9301$
 $\beta_3 = 3.2077, \eta_3 = 83.8157, \rho = 0.9471$



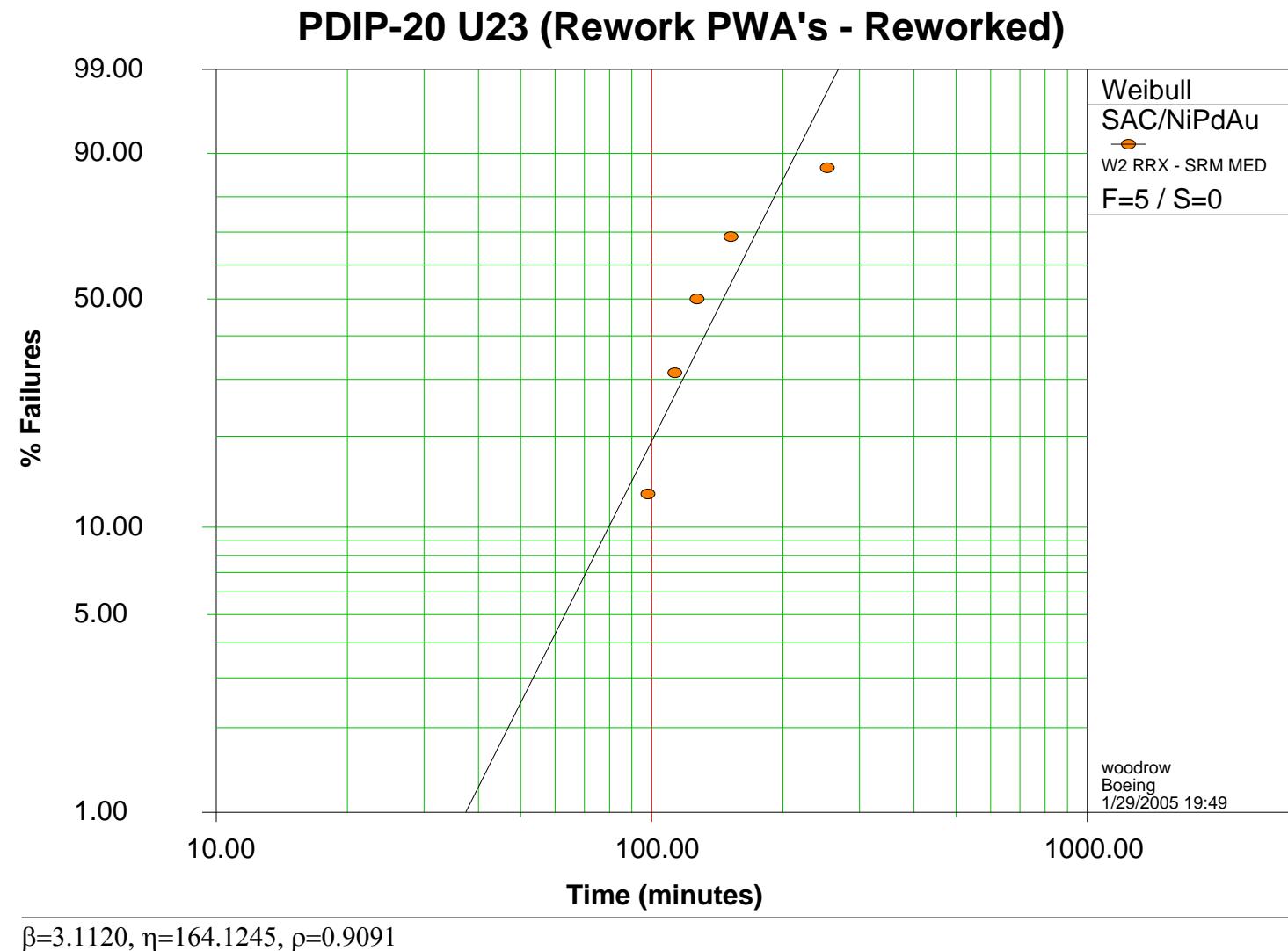
$\beta_1=20.7762$, $\eta_1=413.6937$, $\rho=0.9823$
 $\beta_2=9.6202$, $\eta_2=390.0368$, $\rho=0.9144$

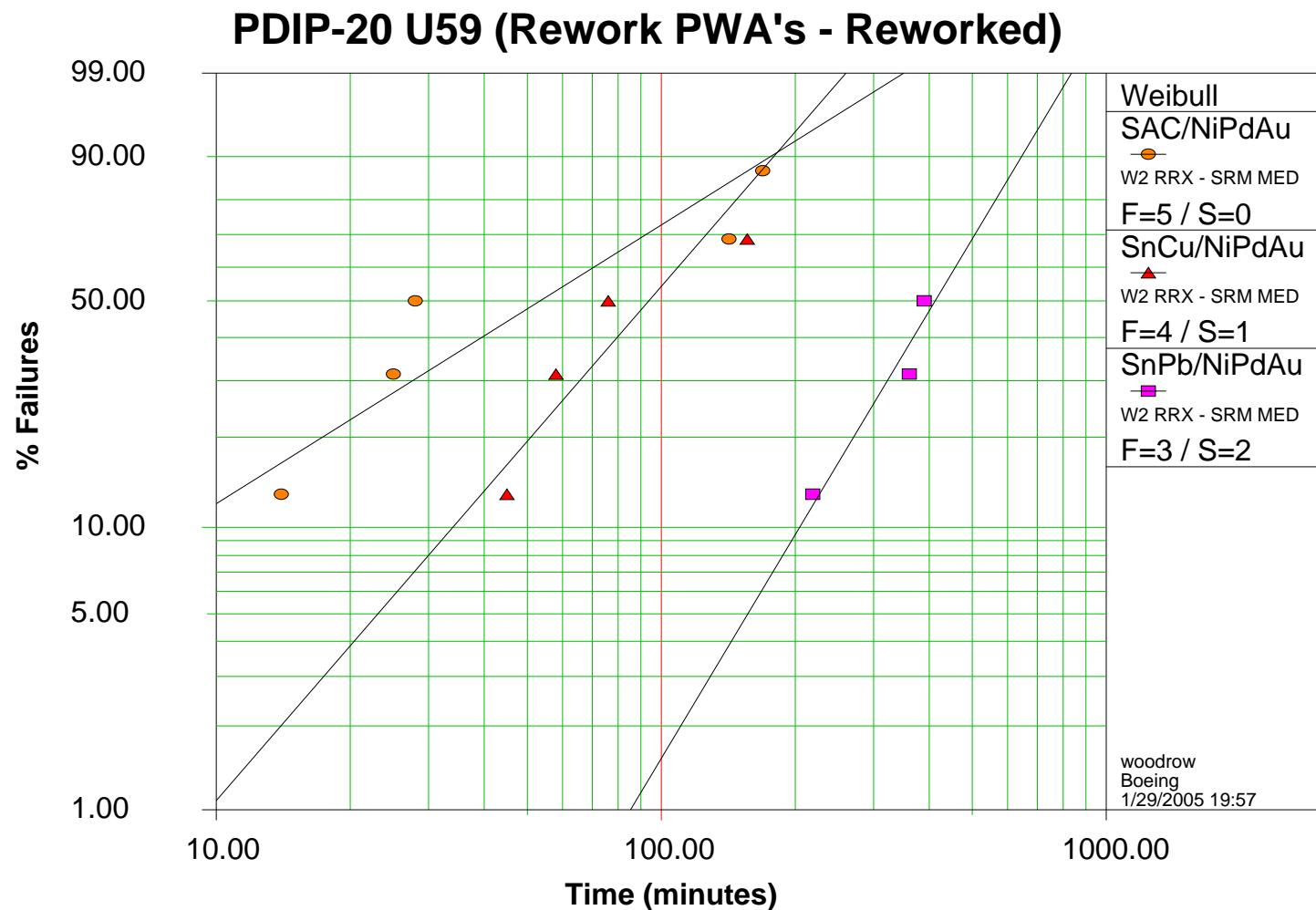


$\beta_1=8.6344, \eta_1=354.5460, \rho=0.9627$
 $\beta_2=3.0699, \eta_2=342.7388, \rho=0.9300$
 $\beta_3=5.0672, \eta_3=434.1210, \rho=0.9817$

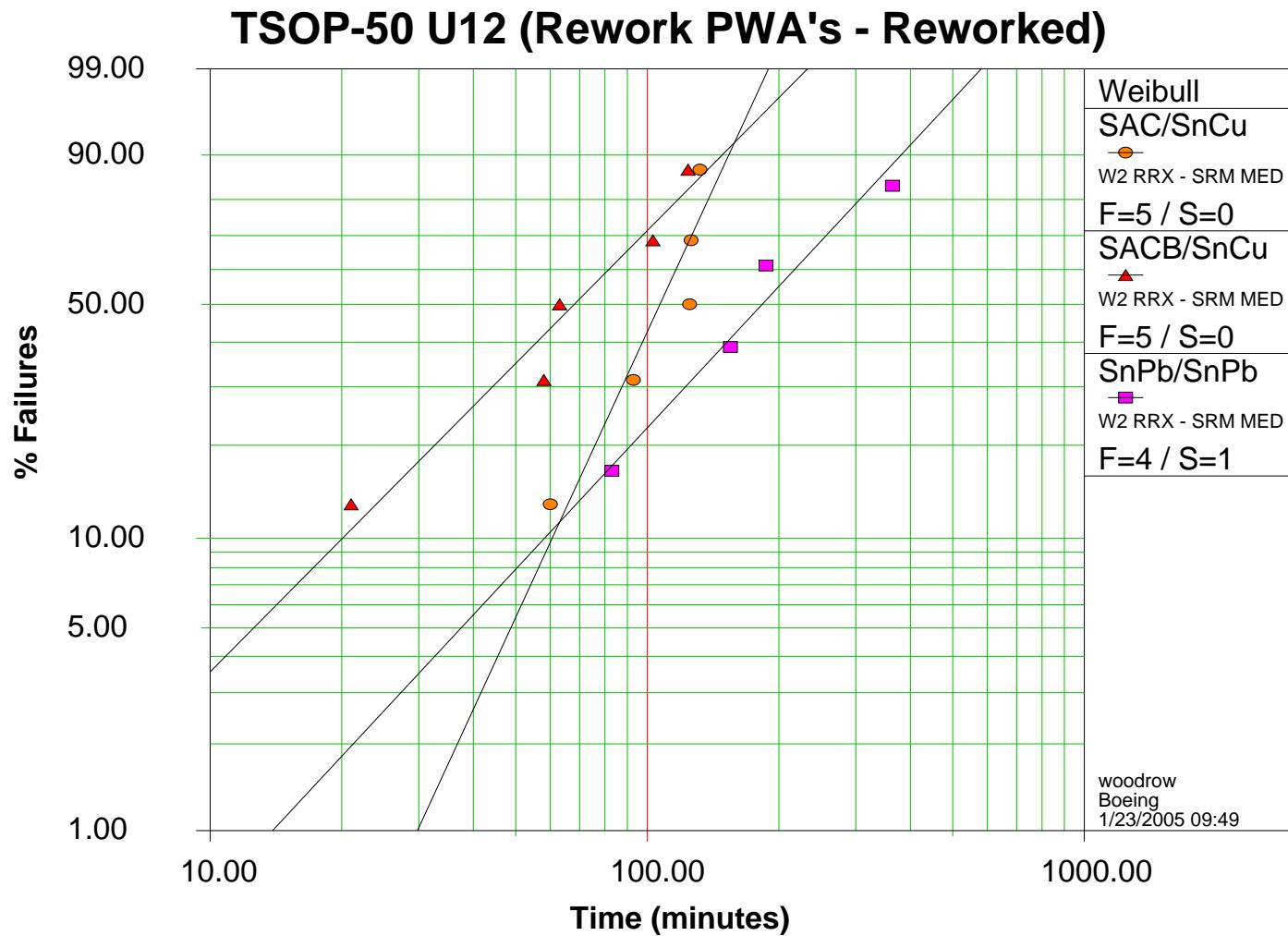


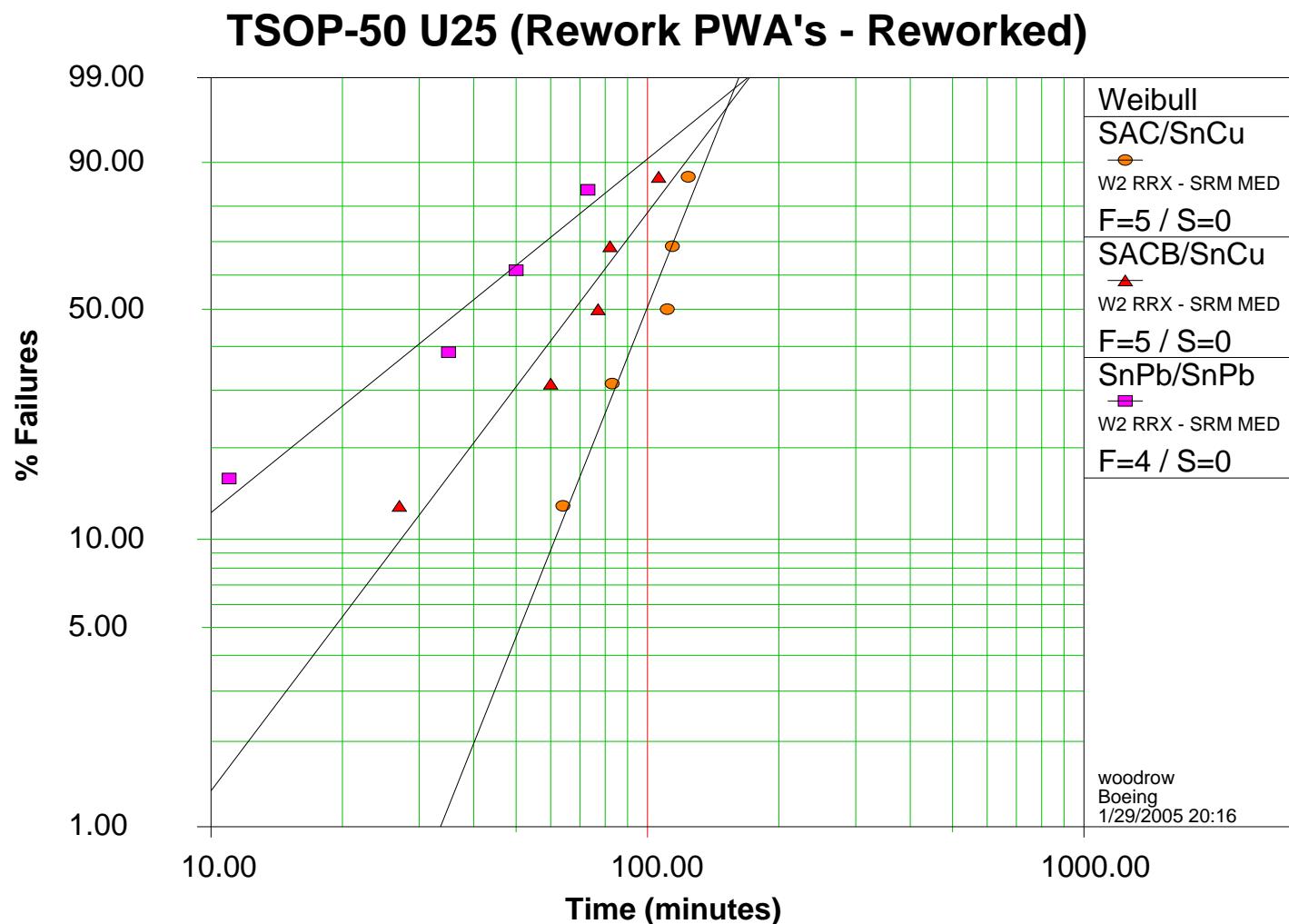
$\beta_1=10.4960, \eta_1=372.7274, \rho=0.9437$
 $\beta_2=19.3276, \eta_2=400.1834, \rho=0.9901$





$\beta_1 = 1.0067, \eta_1 = 76.9511, \rho = 0.9238$
 $\beta_2 = 1.8571, \eta_2 = 114.3042, \rho = 0.9162$
 $\beta_3 = 2.6848, \eta_3 = 473.4770, \rho = 0.9661$





$\beta_1=3.8935, \eta_1=109.3907, \rho=0.9719$

$\beta_2=2.0539, \eta_2=81.4525, \rho=0.9651$

$\beta_3=1.2558, \eta_3=50.3721, \rho=0.9816$